POWER

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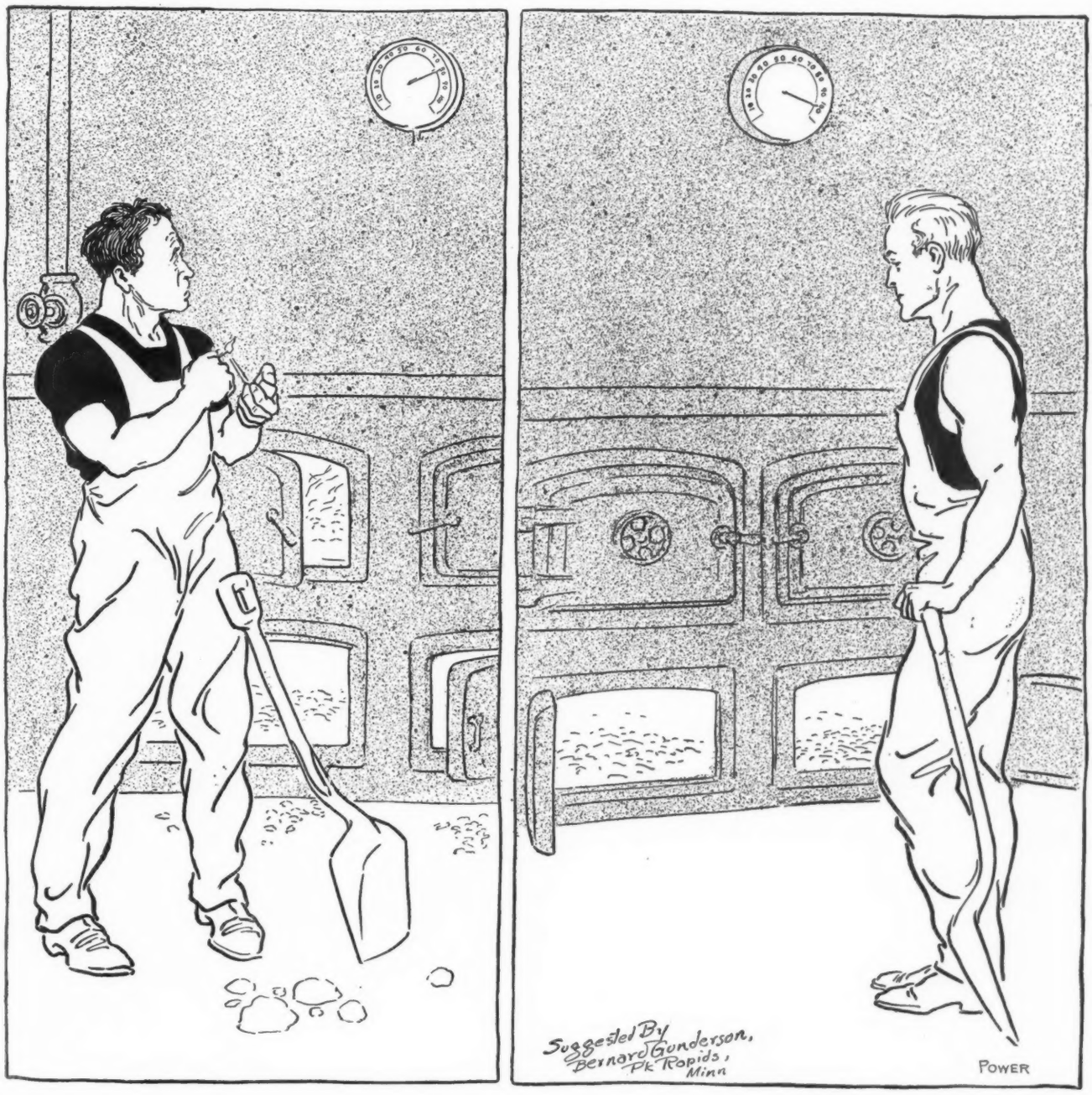

TWO KINDS OF FIREMEN

Completion of the Hale's Bar Works

SYNOPSIS.—Water-power plant, designed for total capacity of 43,862 kw., to supply Chattanooga with current at prices ranging from 1½ to ½c. per kw.-hr. Units consisting of three vertical turbines on one shaft and a lock with the highest single lift in the world are interesting features.

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As two flag-bedecked steamers backed out into the Tennessee River at Chattanooga on Thursday morning, Nov. 13, the whistles of the factories lining the banks sent up a resounding salute. It was the Godspeed of industrial Chattanooga to those who were going to Hale's Bar to formally signalize the completion of the dam and

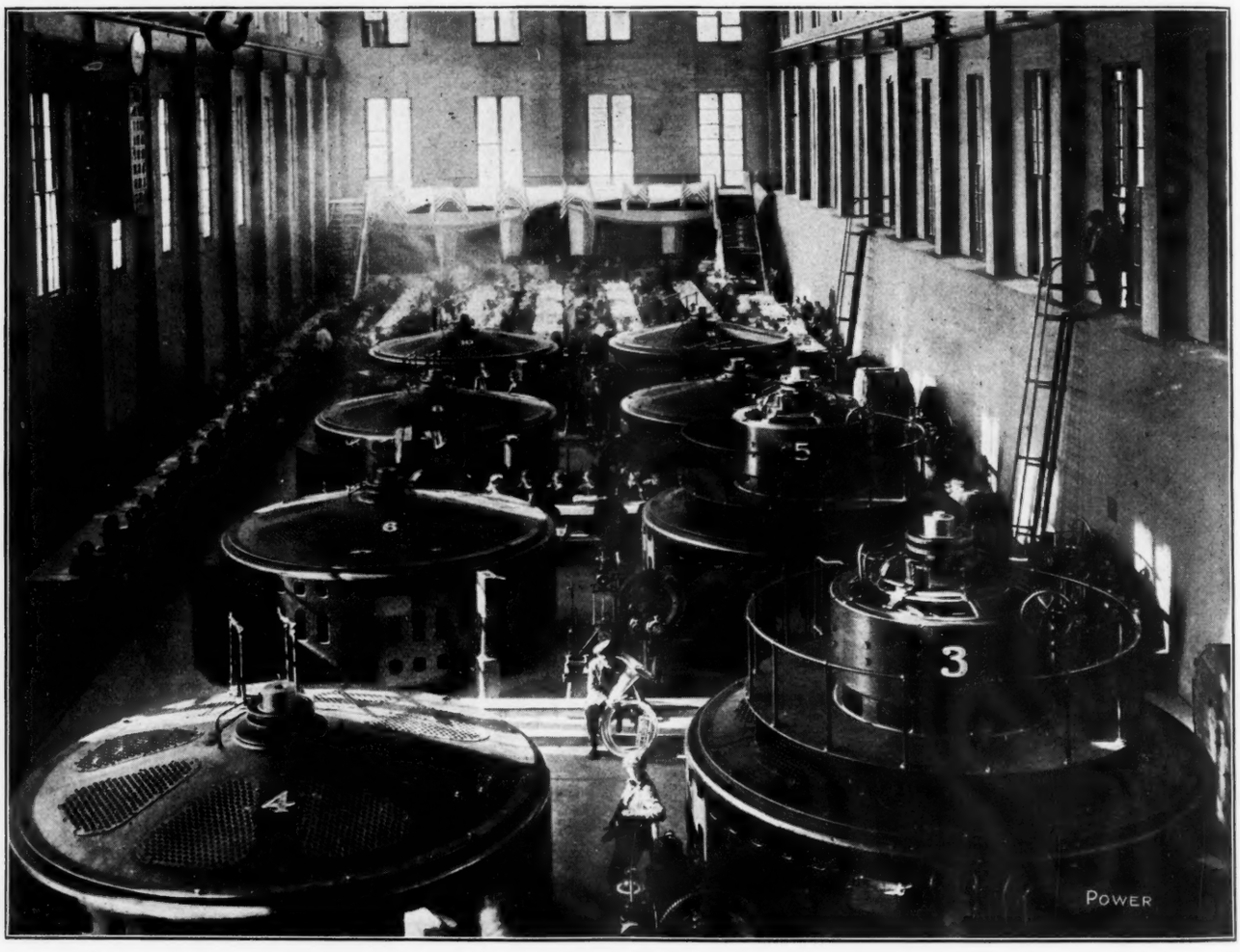


FIG. 1. DURING THE LUNCHEON IN THE TURBINE ROOM OF HALE'S BAR PLANT

hydro-electric development at that point and to establish the connection which should place at the disposal of those industries and others yet to come, a source of low-priced power which shall make Chattanooga, as its hustling Chamber of Commerce puts it, The Dynamo of Dixie.

Hale's Bar is only 12 miles from Chattanooga as the crow flies, but the river winds over 33 miles of country in its devious course through the mountains between these points. This 33 miles has been a stretch of precarious navigation with water enough to afford passage to sizable steamers only eight months of the year.

Dan C. Kingman, now chief engineer of the U. S. Army, suggested years ago, as an alternative to the annual expenditure for keeping the river open, the building of a dam which should regulate its flow and increase its depth. Later C. E. James and J. C. Guild, two progressive citizens of Chattanooga, conceived the idea that the power made available by such a dam would warrant the cost of its construction and in 1904 secured the passage of an act of Congress, authorzing the City of Chattanooga, or others to whom it might delegate the right, to construct such a dam at Scott's Point, the conditions being that an ample lock should be provided for navigation and that the builder should be entitled to the power privileges for a term of 99 years. The city ceded the privilege to Messrs. James and Guild, and they interested the late Anthony N. Brady in the project.

Col. John Bogart and Thomas E. Murray, of New York, were retained as hydraulic and electrical engineers and reported that Hale's Bar, some 17 miles further down the river, would be a preferable site, as it offered a foundation of solid rock and the river widened out at that point and afforded a better egress for the water in times of flood. A modification of the concession was obtained and work commenced at Hale's Bar in the fall of 1905.

Unforeseen difficulties developed in the progress of the work. Extensive clefts and faults in the bed rock re-

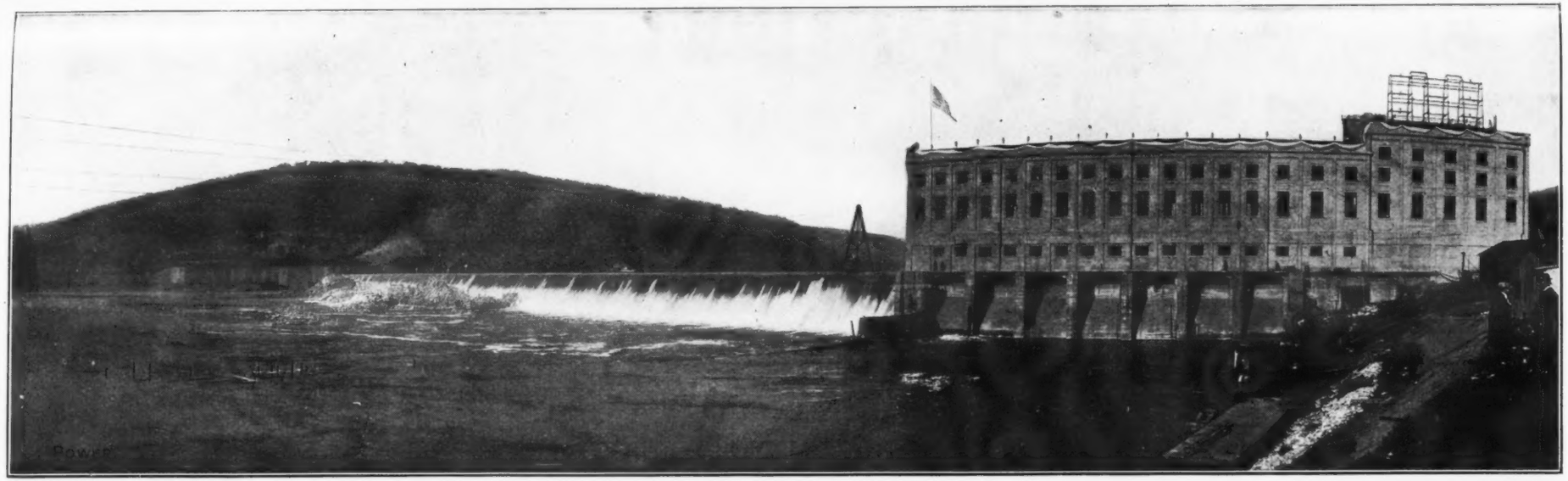


FIG. 2. POWER HOUSE DECORATED FOR FORMAL DEDICATION ON NOV. 13

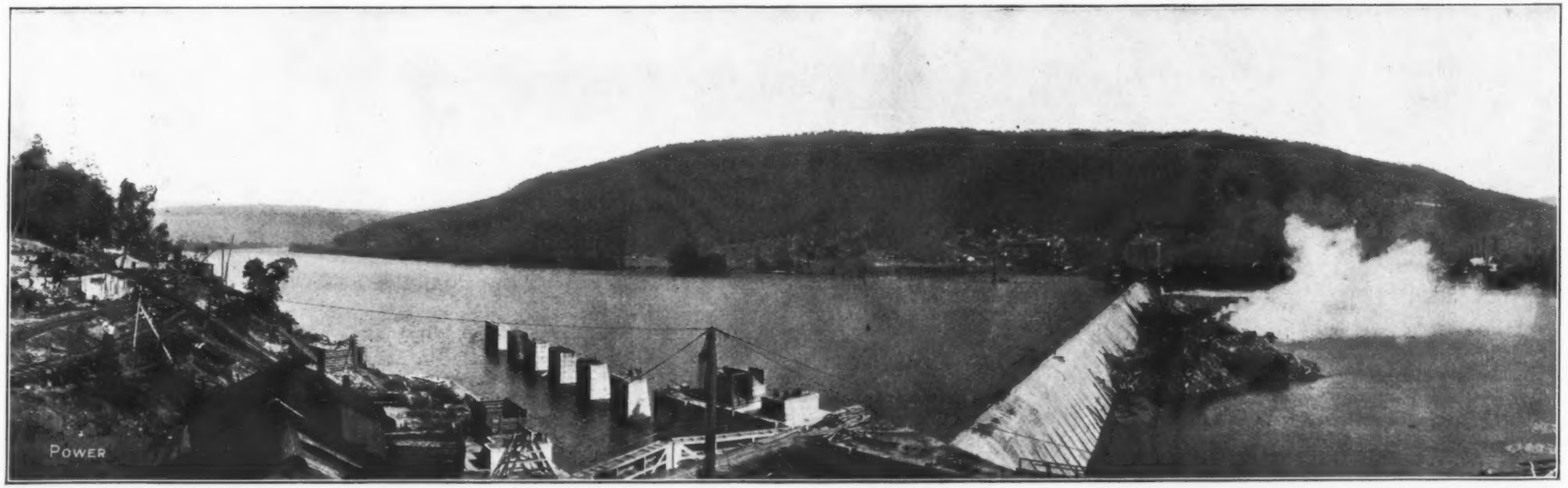


FIG. 3. PANORAMA OF APPROACHES TO LOCK, THE DAM AND POWER HOUSE

quired sealing by the use of some 200,000 bags of cement, and many times the works were drowned out and swept away in the flood stages of the river. Several contractors tried it and gave it up. The cost mounted higher and higher above the estimate, but Mr. Brady stuck it out with his characteristic persistency and the one note of re-

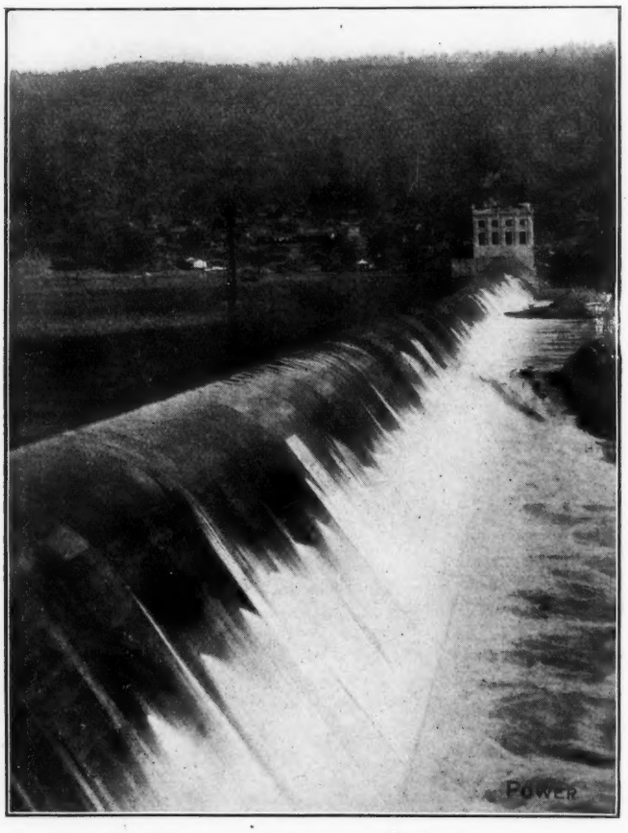


FIG. 4. NORMAL FLOW OVER THE DAM

gret at the occasion which we are reviewing was that he did not live to see the work completed.

In several particulars this development is remarkable. The dam of cyclopean concrete is from 57 to 64 ft. wide at the bottom, 11 ft. at the top and 52 ft. in height. It is 1200 ft. long, and more water passes over it than over any other dam on a navigable river in the United States. The lock is built against a rocky bluff, has an inside length of 310 ft. and a maximum lift of 59 ft. The head upon the gates is greater than that upon those of the Panama Canal. They are constructed of steel and operated by electricity. Each leaf of the lower gates weighs some 129 tons.

The power house of reinforced concrete is located upon the right-hand bank of the river as one looks up stream and is 66 ft. wide by 353 ft. long. Of the length 220 ft. is one story high and contains the turbines and generators. The remaining portions, three stories in height, is devoted to the switches and transformers. The operating section is made up of seven bays, each designed to contain two units, ten of which are already installed.

Each unit consists of three Morgan-Smith turbines mounted upon a vertical shaft with the generator at the upper end. The two lower turbines are 72 in. in diameter, the upper 65 in. Under ordinary stages of the river only the two lower turbines will be used, the third coming into play when the river is in flood and the head reduced by back water. The head at low water is 39 ft., but at the 40-ft. stage of the river the backing up of the tail water reduces this to 19 ft. The turbines run at 112½ r.p.m. and each unit is capable of developing 5250 hp. with a head of 35 ft. The generators have a capacity of 3133 kw. each or 43,862 kw. for the completed station.

The current, generated at 6600 volts, 60 cycles, is stepped up in transformers to 44,000 volts for transmission to Chattanooga where it is expected that the available supply will be absorbed.

At the conclusion of the luncheon with which the visitors, who numbered some 500, were served upon their arrival at the power house, vice-president P. J. Kruesi, of the Chamber of Commerce, and chairman of the celebration committee, described the significance of the occasion in a brief address and introduced Governor Hooper, Mayor Thompson, Ex-senator Newell Sanders, Charles M. Jacobs, of Jacobs & Davies, the contractors, John A. Patten and others who spoke briefly of the meaning of the occasion to Chattanooga.

Finally the company stood at attention while the two little 7-year old grand-daughters of Mr. Brady, Ann Brady Gavitte and Jane Brady, threw the switches, which sent the current into Chattanooga. This event was made manifest to the Chattanoogan by the lighting of the thousands of incandescent bulbs with which Chattanooga's skyscraper, the James Building, named after the sole surviving promoter of the project, had been garlanded, and they stayed aglow all through the afternoon and evening, throwing an unaccustomed glare throughout the business district, typifying the wealth of power that there is now to spare and inviting all to come and partake of its ad-

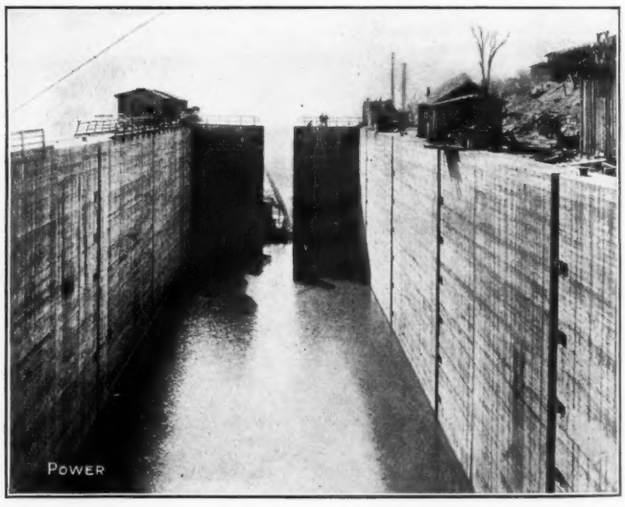


FIG. 5. LOCK AT HALE'S BAR, THE HIGHEST SINGLE LIFT IN THE WORLD

vantages. The current will be sold at the following rates in addition to a fixed monthly charge of $1 per kw. of maximum demand based upon the average of a 7½-min. peak load.

First 2000 kw	1½c. per kw.-hr.
Second 2000 kw	1¼c. per kw.-hr.
Third 2000 kw	1c. per kw.-hr.
Next 8000 kw	¾c. per kw.-hr.
All above 14,000 kw	½c. per kw.-hr.

Byron T. Burt will be the general manager of the plant.

The culminating feature of the day's celebration was a banquet ordered by the Chamber of Commerce to the visitors at the Signal Point Inn on the mountain of that

name. Ex-senator James B. Frazier made a happy toastmaster, and appropriately commenced the postprandial exercises by calling for a rising silent toast to the memory of the man whose faith in the project and courage and persistency in its execution had made possible the event which they were commemorating. Mr. Brady's two sons, the newly elected president of the American Institute of Electrical Engineers; Adolph S. Ochs, proprietor of the Chattanooga and New York *Times;* Charles M. Jacobs, of Jacobs & Davies, the contractors who successfully completed the work, and C. B. James, the parent of the project.

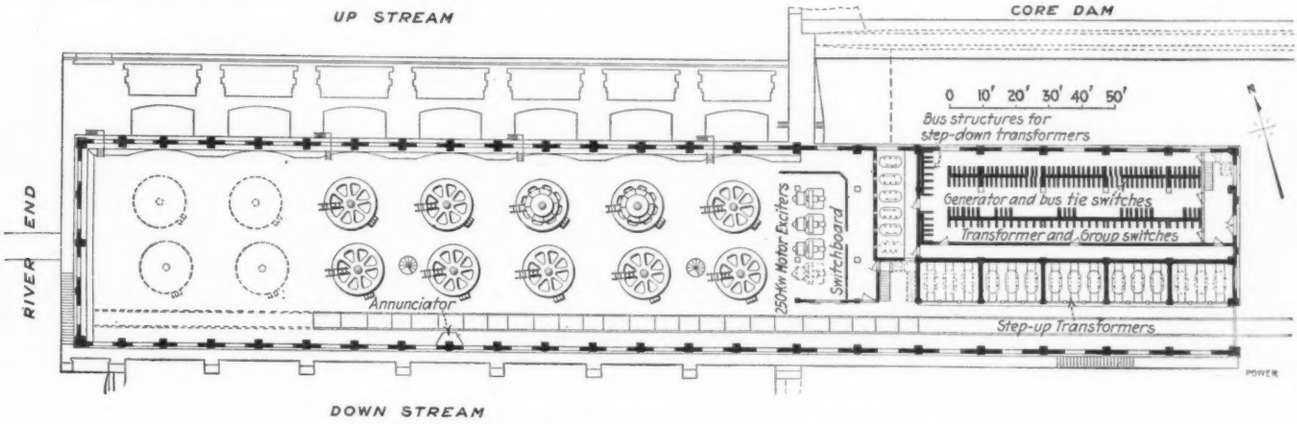


FIG. 6. PLAN VIEW, SHOWING LAYOUT OF POWER PLANT

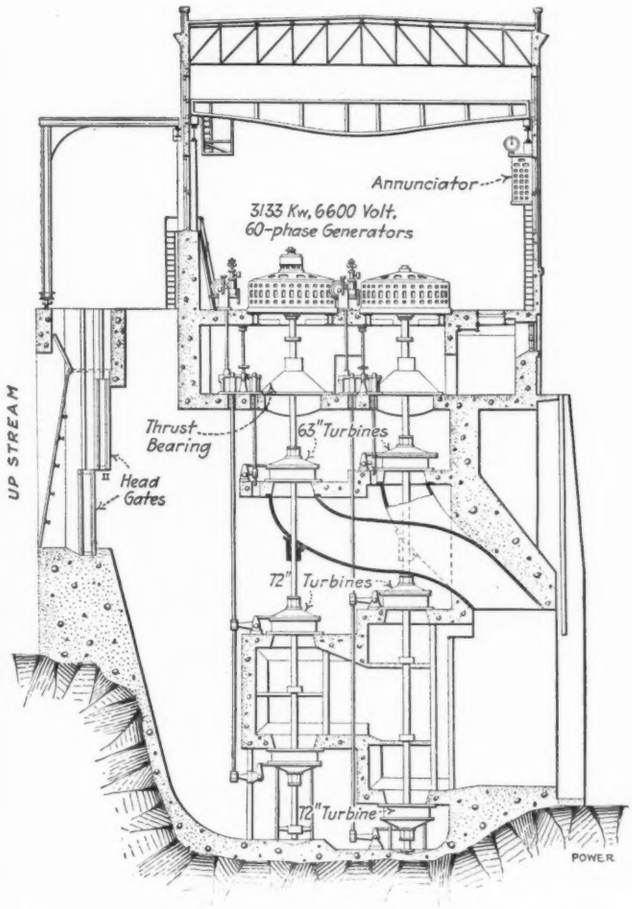


FIG. 7. TRANSVERSE SECTION, SHOWING THE THREE TURBINES ON ONE SHAFT

Nicholas F. and James C., were present. Toasts were responded to by Chief Engineer John Bogart, Speaker E. B. Allman, of the Alabama house of representatives, on behalf of the governor of that state, Governor Ben W. Hooper, of Tennessee, Thomas E. Murray, of the New York Edison Co., who in addition to representing the Brady interests was the representative of C. O. Mailloux,

When the industrial history of America is written this will be recorded as one of the earliest and most notable instances in which industry and commerce joined hands in an enterprise of magnitude which should conserve for the one, a mighty natural asset hereto worse than wasted, and open to the other new facilities for the transportation of the products of the first augmented in volume and value by the new power placed at its command.

No Coal after Eighty Years?

That the life of the anthracite industry in Pennsylvania is only 81 years, if the various estimates upon which he bases his average are correct, was the conclusion reached by M. S. Hachita, chemist of the Lehigh Valley Coal Co., in a speech made before the New York & Western Pennsylvania Coal Merchants Association.

The first estimate he quoted was that of the Geological Survey of Pennsylvania, according to which there were approximately 19,500,000,000 long tons in the ground prior to mining operations in that state. Taking an average of 40 per cent. as the proportion which can be extracted, this would leave 7,800,000,000 tons as the initial supply. Since 1820 the total tonnage mined has been 1,982,961,263, which would leave 5,917,038,737 tons still available.

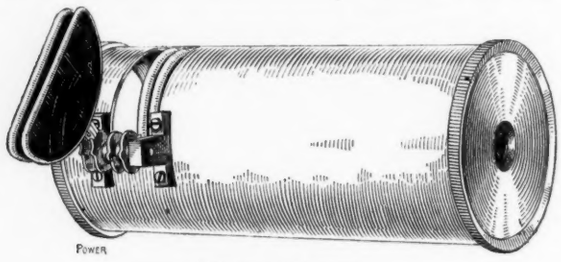
T. S. Harris estimated that there were originally in the ground 14,453,379,600 cu.yd., which is equivalent to 16,766,000,000 tons. By again taking 40 per cent. as the proportion which can be extracted and deducting the total amount mined, 4,823,438,737 tons are left available. A. D. W. Smith, one of the commissioners of the coal-waste investigation, estimated the available supply of anthracite in 1892 at 6,898,000,000 tons. Since then 1,141,684,910 tons have been mined, leaving 5,564,715,090 yet to be mined. In 1896, William Griffith estimated the available coal yet to be mined at 5,073,786,000 tons. Since then 1,096,963,635 tons have been mined, leaving 3,976,832,305 tons in the ground. The average of these four estimates by experts is 5,070,506,217 tons.

Dividing this by the probable consumption, gives the above number of years.

Standard Umbrascope Smoke Tester

This instrument has been designed to use in cities and towns where the smoke ordinances for the regulation of the density of smoke are in force. The method employed in determining the density of smoke is by comparison with smoked glass of certain light-absorbing power.

The tester, or umbrascope, which is manufactured by Williams, Brown & Earle, Inc., 918 Chestnut St., Philadelphia, Penn., consists of a nickel-plated tube, 1½ in.



SMOKE TESTER

in diameter and 4 in. long. Near one end of this tube are four smoked glasses, in the shape of half circles, so hinged that one or all of them may be swung into the tube at once, which clouds the view through one-half of the tube. The clear sky is viewed through the other half of the tube and through as many glasses of specified density as the law requires. A comparison between the glass and the smoke decides which is the darker.

The Miller Rotary Engine

Essentially, the Miller engine, Fig. 1, consists of a circular cast-iron cylinder in which two ring-packed pistons, cast integrally with a hollow disk, revolve. The disk, called the piston disk, revolves in the space between the two inside edges of the circular cylinder. Its sides are perforated to admit steam which gets into the cylinder by issuing through ports in the disk and bottom of the cylinder when the ports are opposite each other. This piston disk is packed against leakage into the cylinder by rings which may be set up against the disk by the set-screws.

The abutments, one of which is shown alone at the top of Fig. 2, resemble a pulley with a solid center, on the opposite sides of which are openings for the pistons to pass through, just as teeth of opposite gear wheels pass each other. As the piston comes through an abutment and the latter closes behind the piston, steam is admitted to the cylinder from the piston disk. The exhaust steam is swept out by the next piston. The effective stroke is the distance between the abutments, thus forming two curved cylinders; the rest of the circle occupied by the

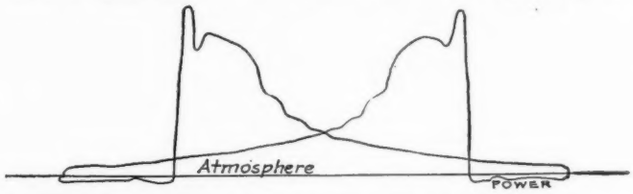


FIG. 3. DIAGRAMS FROM TOP HALF OF ENGINE

abutments is used to exhaust the steam through the abutment openings and out the exhaust pipes connected to the abutment casings. The abutments are packed against the piston disk, all packing being metal and adapted to superheated steam. The design lends itself to compounding, condensing, to automatic cutoff and the engine may readily be made reversible.

The cylinder dimensions of the engine shown, which is noncondensing, are 3x21 in., and the machine is designed to develop 61.6 hp. at 800 r.p.m., and 150 lb. steam pressure. The piston speed at 800 r.p.m. is 4400 ft. per min.

As the effective stroke in one cylinder is 21 in. and each

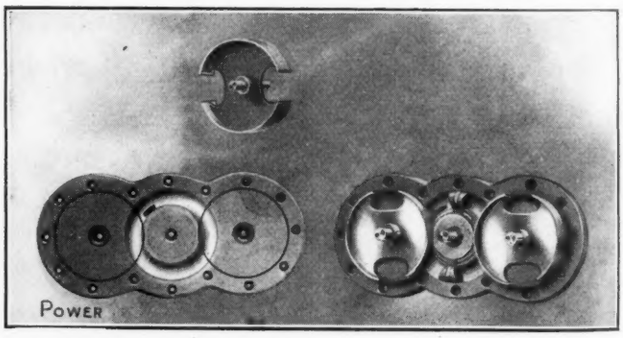


FIG. 2. SHOWING CYLINDER PISTONS AND ABUTMENTS

piston receives two impulses per revolution, the total effective stroke is 84 in.

On the test by Professor Pryor at Stevens Institute the engine developed 52.2 b.hp., at 770 r.p.m., 140 lb. steam pressure, the steam consumption per brake horsepower being 64.1 lb. On a test of the same engine at Columbia University, F. F. Nickel obtained a steam consumption of 64 lb. per b.hp., with 90 lb. initial pressure, very wet steam, and at a speed of 667 r.p.m.

The indicator diagrams shown in Fig. 3 were taken with an ordinary reciprocating-engine indicator and the engine braked down to a speed of 100 r.p.m. The diagrams were taken from the top half or cylinder so that two diagrams were made, one for each piston.

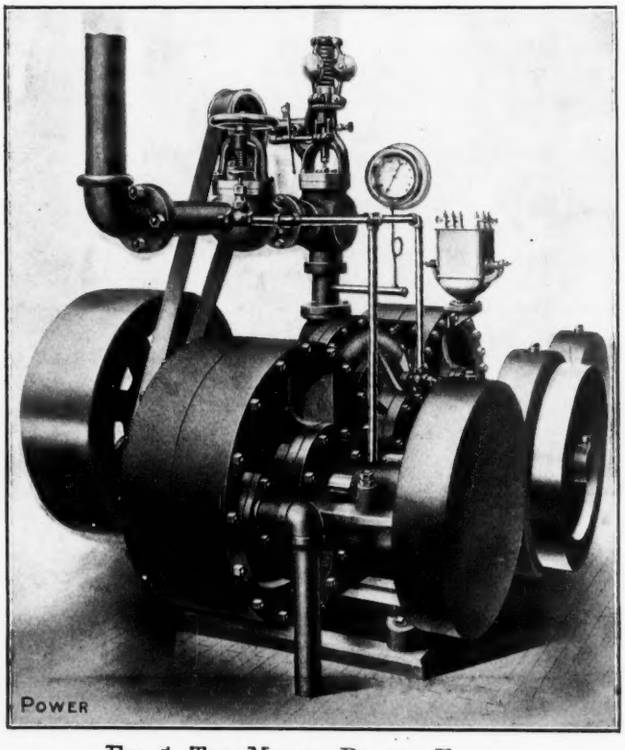


FIG. 1. THE MILLER ROTARY ENGINE

The most economical speed of the engine is much below that of the turbine for the same power and considerably above that of the reciprocating engine, adapting it to various drives without gearing. The engine operates without vibration and is practically noiseless. As to weight, the engine is light per horsepower. The estimated weight of a 240-hp. engine, based on the weight of the present engine, is 4800 lb.

The inventor hopes to develop a rotary gas engine of the same general design.

The experimental engine was made by the Miller Motor Co., 132 East 237th St., New York City.

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Tests of a Simple Noncondensing Lentz Engine

By Prof. J. A. Moyer*

SYNOPSIS—Describes the method and results of four tests of a Lentz engine of 250 hp. capacity, which with about 155 lb. gage pressure and 140 deg. superheat, showed a steam rate between 15 and 16 lb. per i.hp.-hr., which means around 85 per cent. Rankine efficiency. So far as we know these tests establish a new record for simple noncondensing engines.

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From July 30 to Aug. 6, 1913, I witnessed, as an entirely disinterested party, a series of tests, which were made on a simple horizontal Lentz engine, of which the cylinder diameter was $19\frac{1}{2}$ and the stroke was $20\frac{15}{16}$ in. These dimensions were taken by myself with accurate scales when the cylinder was hot. The piping arrangements for making a test of this engine for noncondensing operation are shown in Fig. 1. The exhaust steam was condensed in a battery of four closed feed-water heaters, supplied with cooling water from the city mains. The condensates were taken away in short pipe lines and discharged alternately into suitable weighing tanks on Fairbanks scales. For the purposes of this test these scales had been calibrated, corrected and certified by the Department of Weights and Measures of the city of Erie. The power from the engine was absorbed by a 300-kw., direct-current electric generator belted to the flywheel. The temperature and pressure of the steam at the engine were measured where the live-steam pipe entered the steam

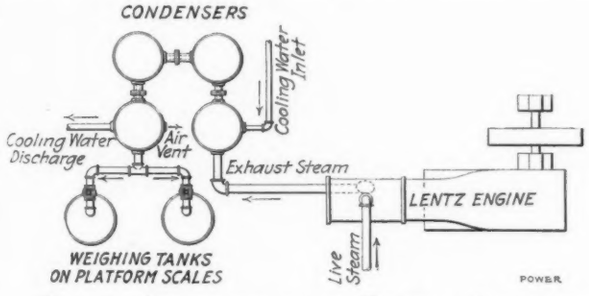

Fig. 1. Arrangement of Testing Apparatus

chest. The speed of the engine was taken very accurately by a hand speed counter when the indicator diagrams were taken, and checked with the readings of a continuous engine counter. The current was absorbed in a large water rheostat arranged for accurate adjustment of the load. Readings were taken of ammeters and voltmeters in the power line to check the accuracy of the indicated horsepower determinations, assuming reasonable losses for the belt and generator. These electrical instruments were calibrated by the testing laboratories of the General Electric Co., just before starting the tests. Readings of all instruments were taken at 10-min. intervals and throughout all the tests the conditions remained remarkably constant even as regards the degree of superheat and the wattage absorbed by the water rheostats. This matter of the relative constancy of the readings of the ammeter between the 10-min. observations received my careful attention, so that I am certain that the conditions were uniformly good. The water supply of the feed-water heaters used as condensers

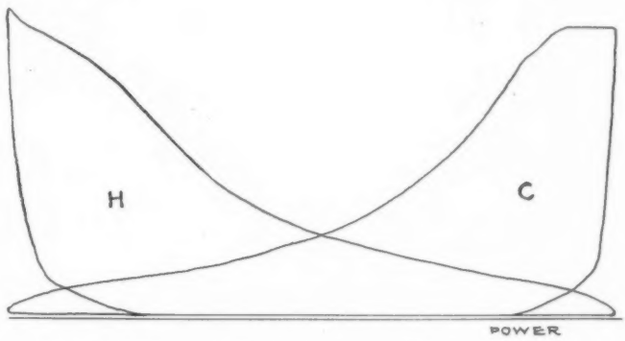

Fig. 2. Typical Diagrams from Lentz Engine

was carefully regulated so that all the steam was condensed. The air vent shown in Fig. 1 discharged into the testing room. If the steam had not been entirely condensed it would have been observed here.

One indicator was attached to each end of the cylinder with the shortest possible connection. These indicators were calibrated before the tests by their makers, again after the test by the Pennsylvania Engineering Experiment Station. The average of the two calibrations, which were in very good agreement, has been used in calculating the indicated horsepower. The areas of the indicator cards were measured with planimeters which have been checked for accuracy by the measurement of easily calculated geometrical areas. The special precautions enumerated above make the results of the calculated indicated horsepower of practically unquestionable accuracy.

As will be observed in the tabulated results, the most important tests were run with unusually constant conditions for periods of from three to four hours, so that the most skeptical should be convinced of the uniformity of the data and the accuracy of the results for long periods.

The thermometers used for determining the temperatures for both the live steam and the exhaust were carefully calibrated with standard thermometers and checked with the temperature given in the steam tables as corresponding with the observed pressures of saturated steam. Stem exposure was observed in all cases and the corre-

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sponding corrections were made by the generally accepted methods.*

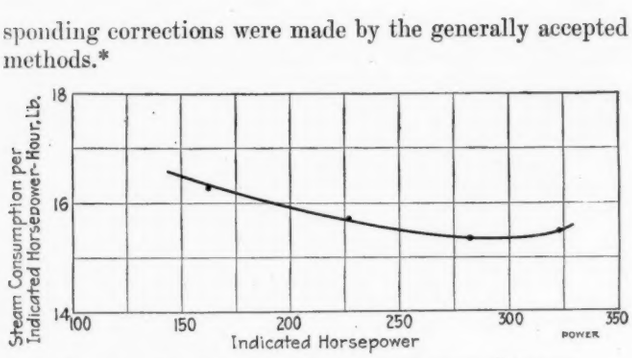


FIG. 3. RESULTS OF TEST OF LENTZ ENGINE

Fig. 2 shows typical indicator diagrams taken during the test.

The following table is a compilation of the important results of this series of tests:

RESULTS OF TESTS ON A SIMPLE LENTZ ENGINE

No. of test.	Duration of test, hours.	Speed, r.p.m.	Mean Effective Press., Lb. per Sq.In.** H.E.	C.E.	I.hp.	Steam per i.hp. per hour, lb.	Absolute steam pres., lb. per sq.in.	Back press., inches of mercury.	Superheat, deg. F.
1	4	208	46.35	45.92	282.1	15.24	170.3	0.34	141.5
2	3	208	24.83	28.40	162.7	17.25	170.1	0.00	98.3
3	3½	211	36.19	37.08	227.6	15.78	171.9	0.00	139.4
4	1†	207	53.40	52.22	322.5	15.48	171.7	0.10	159.7

**Calibrated scales of springs of indicators are respectively, 78.9 and 79.3 lb. per sq.in.

†Generator would not carry load for a longer time on account of heating.

It will be observed from the above table that the superheat for test No. 2, which was run at the lightest load for the series, could not be maintained as high as for the other tests on account of difficulties in boiler operation.

*"Power-Plant Testing," second edition, pages 36-38 (McGraw-Hill Book Co., New York).

In order to correct the steam consumption for this test and make it correspond as regards the amount of superheat with the others of the series, another set of tests was run during which full load was maintained on the engine and only the superheat was varied. A curve plotted from the results of these tests showed that the steam consumption was 6 per cent. lower at 147 deg.†† superheat than at 98. As the result of this correction the steam consumption of test No. 2 on the basis of the average superheat for the other tests is 6 per cent. less, or 17.25 — 1.03 or 16.22 lb. per indicated horsepower per hour. After making this correction all the tests are in very good agreement as regards superheat, back pressure and steam pressure. The final results as corrected for superheat are plotted on the curve shown in Fig. 3.

I believe these data indicate that this engine has shown the lowest steam consumption yet attained under satisfactory test conditions with a simple engine operating noncondensing, and that, therefore, the results are most important.

See brief report of tests in POWER, July 15, page 105, and criticism thereof by Mr. Hyde, on page 443, of Sept. 23.

††The average of tests 1, 3 and 4.

Cleanliness and Efficiency in a German Power Plant

Economy, as regards fuel, is the one thing most sought after in German power plants, writers L. B. Webster in the American Gas & Electric Co.'s *Bulletin*. Coal, which can be laid down in plants in the United States for from $1.50 to $2.50 a ton, brings from $6 to $8 a ton, or even more, in Germany, where good fuel is not so plentiful as

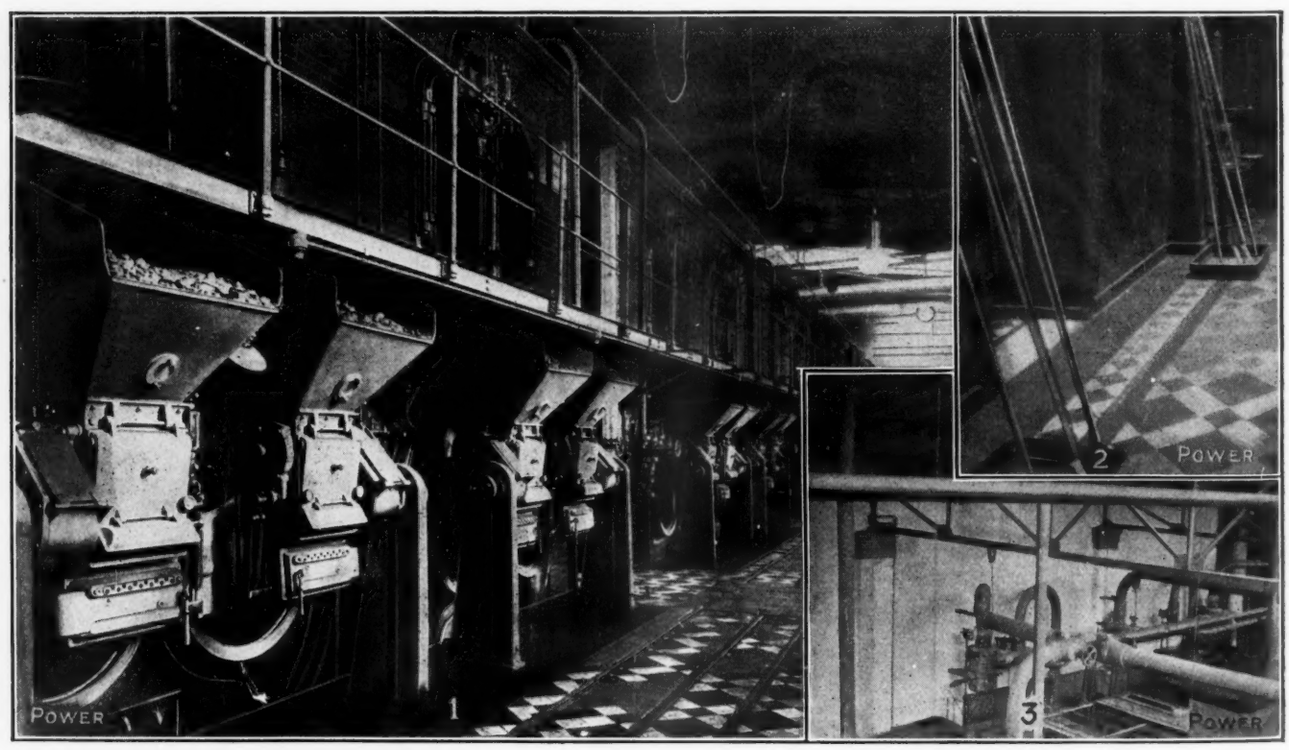


FIG. 1. VIEW IN BOILER ROOM. FIG. 2. HOW THE POKERS ARE CARED FOR. FIG. 3. SOME OF THE PIPING OVER THE BOILERS

it is in this country. As a result of the high price of fuel, coal and partly burned refuse are never seen scattered about, and every part of the typical German power plant is kept spotlessly clean.

In Fig. 1 is shown a view in the boiler room of the electric-light plant of the city of Munich, the capital of Bavaria, the largest and most progressive city in southern Germany. The boiler equipment of this plant consists of 32 internally fired boilers of 230 hp. each. These boilers are equipped with automatic stokers of the overfeed type; that is, the stokers throw the coal on the fuel bed in much the same way as a fireman does with a shovel. The work of firing, water tending and handling of reclaimed coal is done by a force of three men on each shift. In order for this small force to properly take care of such a large number of boilers, all equipment is arranged so that the men can do their work with the least possible expenditure of time and effort.

As an example of how carefully the operating problems in this boiler room have been worked out, Fig. 2 shows how the pokers and fire irons are cared for. Each pair of boilers has its complete set of pokers standing against the boiler-room wall in an iron tray, for the sake of keeping the boiler-room floor clean.

In Fig. 3 is shown some of the piping over the boilers and part of the main steam header along the engine-room wall.

Plenty of light and space have been provided over the boilers, where in so many plants in this country, the piping is often cramped and hard to get at. In Fig. 3, it is interesting to note, the piping is shown to be spotlessly clean.

Condenser-Tube Corrosion—I.

SYNOPSIS—The Corrosion Committee of the Institute of Metals has examined the question of corrosion by getting reports from operating engineers, by laboratory experiment, and by work on a small condenser plant. An abstract follows of their methods, and of such results as seem to touch most closely the operating engineer. The report is the work of Guy D. Bengough and Richard M. Jones.

It seems well to supplement the report of the committee on steam turbines of the Association of Edison Illuminating Companies, printed in the Oct. 14 issue, with a report of the work of the British Institute of Metals.

The time-honored method of investigation of this problem is to obtain information from the engineers in charge of condenser plants, and a number of blanks were sent out by the committee. The tubes on which reports were rendered were all 70:30 brass, or 70:29:1 tin alloy. The chief points of interest which could be deduced from the engineer's reports were:

(1) The extraordinary variation in the normal life of a tube, viz., from four to 25 years. Supplementary inquiries conducted by the authors have proved conclusively that tubes from the same batch made by one manufacturer, when placed in different parts of a condenser, might resist corrosion for times which vary up to the proportion of 1:3.

(2) The peculiar nature of the deterioration that resulted in the failure of the tube. In nearly every case the deterioration was due to dezincification, resulting in a rotten and pitted tube. In two or three cases tubes failed, owing to local thinning, due, apparently, to the wearing away of the whole body of the tube near the water-inlet end. This phenomenon was comparatively rare.

(3) The impossibility of correlating the failure of the tubes with the presence or nature of the electric-lighting installation.

(4) The difficulty of connecting corrosion with any definite locality in the tube or condenser, though it would appear as if thinning were connected with the ends of the tubes at which the cooling water entered.

(5) The shorter life of tubes in land installations, where dock, canal, or brackish water is used instead of sea water. Nevertheless, the Corrosion Committee, for good reasons, desired investigations in the first instance to be carried out with natural sea water, and this has been used in all experiments described, except where the contrary is stated.

Detailed examination of the scale attached to the tubes was made. In normal cases it could be regarded as made up of several layers of different composition. The top layer consisted principally of ferric oxide, carbonates, and chlorides of calcium and magnesium, calcium sulphate and sand; the next layer consisted of basic chlorides and carbonates of copper and zinc, and was greenish in color. The layer next the tube was brown or black, and consisted largely of cuprous and cupric oxide. There was, of course, no sharp line of demarcation between the various layers, which faded gradually into one another, sometimes the greenish-blue layer was almost absent, especially when dezincification had been severe. In most cases the scale, particularly the lowest layer, was strongly adherent to the tube. In all cases, in which a tube had suffered dezincification the greenish-blue layer was replaced, to a greater or less extent, by a white flocculent salt, which was found to be a basic chloride of zinc.

In one or two cases tubes were received partially choked with a loosely adherent deposit, light gray in color. This was found to be principally sand, but contained also ferric oxide, magnesium salts, and calcium salts. Such tubes sometimes appeared to be more severely corroded than others taken from the same condenser, but not always.

Careful search was made among the deposits in badly corroded tubes for carbon particles. Although about a hundred cases were examined no such particles were ever found, and in no single instance could a dezincified spot or area be correlated definitely with such a particle. This, of course, does not prove that carbon in the form of graphite or coal had not started the dezincification of the tubes since it might subsequently have been removed when the tube was cleared by means of an iron rod or brush.

As a result of the study of the answers to the question schedules and of the tubes corroded under conditions of practical work, the authors came to the conclusion that few deductions of importance could be made, and that this method of work is only of value for indicating in a general way the nature of the problem to be attacked.

Laboratory Investigation

In arranging their somewhat extensive laboratory scheme the authors had to investigate two distinct forms of corrosion: "Complete" or the gradual wearing down of the tube, the copper and zinc being removed in the proportions in which they occur in the alloy; "selective," in which dezincification occurs, followed by pitting. The zinc is removed preferentially, leaving a rotten, copper-enriched area.

The tubes on which experiments were made had the following compositions:

		Condenser-Tube Compositions				
		Cu	Zn	Sn	Pb	Fe
I	70:30 Brass	70.20	29.17	....	0.27	0.27
II	70:28 Brass	69.94	27.60	....	2.08	0.28
III	61:39 Muntz Metal	60.90	38.21	....	0.46	0.33
IV	70:29:1 Admiralty Brass	71.18	27.28	1.07	0.28	0.21

In the first series of experiments, cleaned plates of these compositions were suspended by glass hooks in beakers of sea water, at ordinary room temperatures, 64 to 68 deg. F. The oxygen in the water was simply that which could diffuse in from the air. It soon became evident that the first stage of the corrosion of brass is the oxidation of one or both of the constituent metals. Cohen's observations are confirmed, *in the absence of oxygen there is no corrosion.* In this series of experiments, admiralty brass was most corroded; 70:28:2 brass next; 70:30 brass next; and Muntz metal least. The percentage losses after 208 days were for the four metals respectively:

Upper tubes	1.04	0.61	0.50	0.31
Lower tubes	1.02	0.55	0.45	0.27

The greater loss of the so called "upper tubes," the plates covered by the less water, is due to the greater amount of oxygen present in the upper layers of water. Experiments suggested by these results were made with aqueous solutions of carbon dioxide, and it was also determined that waters highly charged with this substance were corrosive to brass.

However, the result of these experiments at ordinary temperatures seems to be contained in this statement:

It has been suggested from time to time by engineers and others that sea water remaining stagnant in the tubes has a specially rapid corroding effect on them. Supposing no pitting to take place, and assuming that a tube could be used till it had lost two-thirds of its thickness, that corrosion takes place on one side only of the tube, and that it proceeds uniformly at the same rate, the life of a 70:30 tube should be about 75 years. In practice the life of a tube rarely reaches 25 years, and the normal life of a tube may be taken to be about 12 years under average conditions.

This corrosion by stagnant water is in all cases general and not selective.

Corrosion at Higher Temperatures

These immersion experiments were continued at higher temperatures, and one fact of predominating importance was immediately brought out: At 104 deg. F., brass tubes of any type are dezincified by sea water. The order of corrosion was: Muntz metal (least resistant), 70:30 brass; 70:29:1 tin; 70:28:2 lead. Dilution of the sea water tends toward selective corrosion; concentration of the sea water retards it. The effect of higher temperature is so marked that even at 77 deg., selective corrosion of 70:30 brass becomes evident after a few weeks, and only one of 20 different samples could remain in sea water at 104 deg. and not show signs of selective corrosion in a month.

At this temperature, loss in weight and corrosion by dezincification do not proceed *pari passu.* [The operating engineer should remember this in making tests of such alloys, as it is dezincification which will determine the giving away of the tubes.—Editor]. Thus, Muntz metal which is most readily dezincified loses least in weight.

Experiments at Higher Temperatures

Experiments were carried on at 122 deg. also, since observation of the outlet water on condensers in service showed that this temperature must often be reached at some points along the tubes. These experiments were run chiefly on the 70:30 and 70:29:1 alloys. The 70:30 tubes showed clear signs of dezincification after seven days' immersion; the 70:29:1 showed no signs at the end of six weeks. Since this alloy showed some slight signs in 104 deg. after three weeks, this result is remarkable, and indicates that there is only a limited range of temperature in which dezincification can take place. It appears that the presence of tin in the brass exerts a powerful effect in preventing selective corrosion.

The Experimental Condenser Plant

For a thorough examination under working conditions a plant was erected, consisting of a boiler working normally at 125 lb. per sq.in., a double-expansion engine, and a condenser, consisting of four sections, each of which contained 12 tubes. The sea water used was contained in an open tank and subject to free aëration, but not to contamination by rubbish; approximately its composition was: Sodium chloride, 2.81 per cent.; magnesium chloride, 0.21; potassium chloride, 0.17; magnesium sulphate, 0.11; calcium sulphate, 0.08; calcium carbonate, 0.02 per cent.

The tubes were of the same composition as those in the laboratory experiments. The vacuum in the condenser occasionally reached 25 to 27 in., but usually did not exceed 20 in. The steam condensed per hour was approximately 5 lb. per sq.ft. of condenser surface. The plant was closed after nine months' working, and three tubes removed from each section for examination.

Nature of the Scale

In all cases the tubes were covered with a brown layer, which consisted chiefly of ferric oxide; it contained also sodium chloride and calcium carbonate, as well as traces of sulphate. This layer was loose and easily removed from the tube. Beneath it a rather more adherent layer was found. This was greenish in color, and contained both copper and zinc in the form of basic chloride and carbonate. In places small white spots or particles of zinc oxychloride replaced the green layer, and the tube underlying these areas was found to be dezincified. In the case of the Muntz-metal tube, the green layer was normally absent and was replaced by a thin gray-white layer of zinc oxychloride. Beneath the layer of basic salts, a layer of brown or black oxide, strongly adherent to the tube, was found in all cases. In no case were any particles of graphite found amongst the scale. Evidently such particles as result from the dissolution of the cast-iron water ends are washed away in the stream of sea water.

Results of the Examination of the Tubes

Admiralty Tubes, 70:29:1

TOP TUBE—Dezincification in irregularly-shaped spots and areas, mainly along the bottom and sides of the tube, but extending for about 8 in. on each side of the center.

MIDDLE TUBE—Dezincification mainly along one side of the tube. Extends for about 6 in. from center.

BOTTOM TUBE—No signs of dezincification.

Special Brass, 70:28:2

TOP TUBE—Dezincification at sides only. Not very pronounced. Mostly near center of tube.

MIDDLE TUBE—A few scattered dezincified spots only. Distribution around tube irregular. Mostly near middle.

BOTTOM TUBE—No signs of dezincification.

Brass, 70:30

TOP TUBE—Dezincification in spots along bottom and sides of tube, extending a considerable distance from the center.

MIDDLE TUBE—In spots, mainly along bottom of tube. Interior surface of tube uneven and dezincification appears to take place on the raised portions.

BOTTOM TUBE—A large dezincified area at top of tube, near center. Dezincification extends a few inches from center of tube.

Muntz Metal, 61:39

TOP TUBE—Severe dezincification in spots. In some places dezincification has almost penetrated through the tube. Especially noticeable along sides of tubes. Most severe near center.

MIDDLE TUBE—Numerous dezincified spots. One large

area 2 in. from center. Dezincification has penetrated one-third through the tube in one or two places.

BOTTOM TUBE—A few small spots at top of tube.

NOTE—The formation of a pit appears to take place in the following way: The zinc is removed from certain spots in the tube, and leaves behind the copper in a loose, spongy and rotten form. When dezincification has penetrated right through the tube, and the copper has lost its backing of unaltered brass, it is quickly worn away mechanically. Mechanical, and to a certain extent chemical, action also removes some of the copper even before dezincification has penetrated right through the tube. This is shown by the measurements of the depths to which the coppery area is depressed below the general level of the surface.

The most important deductions which the authors consider may be drawn from this series of observations are:

1. THE ORDER IN WHICH THE TUBES RESIST DEZINCIFICATION—The most resistant were the 70:29:1 and the 70:28:2 tubes. These appear to resist the action to about the same extent, and were considerably more resistant than the 70:30 brass, which came next in order of merit. The Muntz metal tubes were decidedly the most quickly attacked.

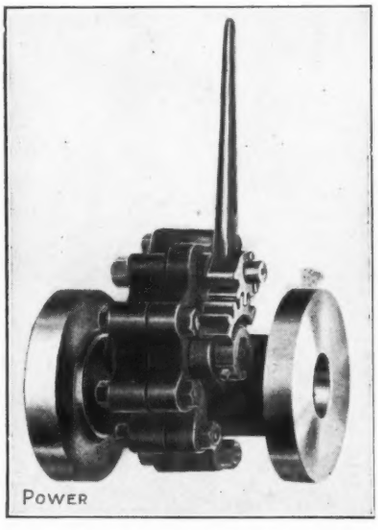
2. THE IMPORTANCE OF TEMPERATURE IN CORROSION PHENOMENA—In all cases the attack appeared to be most severe at or near the centers of the tubes. Since the steam entered the condensers at the center and no baffle-plates were used, the tubes must have been subjected to the highest temperatures at their centers. It becomes evident, therefore, that temperature plays a most important part in determining the distribution of the areas of dezincification.

3. CORROSION IS NOT CONFINED TO THE BOTTOM OF THE TUBES—It usually occurs in that position, but is by no means confined to it. It frequently occurs along the sides, and occasionally along the tops of the tubes.

4. GRAPHITE PARTICLES CANNOT BE REGARDED AS A CAUSE OF DEZINCIFICATION—Dezincification can occur independently of the presence of these or any other foreign particles.

Everlasting, Slow-Opening Blowoff Valve

One of the objections engineers have to straight-way, quick-opening, blowoff valves is that a careless, inexperienced fireman may close the valve so quickly as to produce water-hammer in the blowoff pipe.



SLOW-OPENING BLOW-OFF VALVE

The standard Everlasting blowoff valve is opened and closed by pulling the operating lever one-quarter turn. The slow-opening valve of the same type, also manufactured by the Patterson-Allen Engineering Co., 2 Rector St., New York, requires one-half turn of the lever to open or close the valve.

Referring to the accompanying illustration, the standard type of valve is fitted with a lever and pinion, which swing on a stud, secured to the body of the valve. The valve stem is provided with a rack, the teeth of which mesh with those of the pinion. Because of the difference in the diameter of the toothed circle, it is necessary to pull the lever through one-half of a revolution to fully open or close the valve, thus requiring twice the time to open or close it over the standard type of valve.

Rolling-Mill-Engine Flywheel Explosion

BY J. W. LEHMAN

The bursting of a 50-ton flywheel of a 1500-hp. engine at the American Rolling Mill Co., Zanesville, Ohio, fatally injured J. F. Kennison, day engineer, and will close down the plant for approximately 40 days. The accident took place at 11:55, a.m., Oct. 24.

Engineer Kennison, at the risk of his life, when the engine began speeding up, rushed to the throttle and had partly closed it when the crash came. He was buried under the débris and was later removed unconscious to a near-by hospital with a fractured skull and died later.

A gang of 20 men who were working near the engine quit work 25 min. before the crash. The flywheel was broken into small pieces. A part of the wheel, weighing approximately eight tons, was thrown a distance of 150 ft. A part of the roof was destroyed and the building was generally damaged. An investigation as to the cause of the accident is being conducted by the officials of the company. The engine proper was little damaged.

Reduced Condensation 76 Pounds per Hour

As a result in the kind of covering used on the steam pipes in the water-works plant of Middletown, Ohio, the condensation was reduced 76 lb. per hour.

According to the H. W. Johns-Manville Co., tests extending over a period of several months were made of the principal pipe covering and insulating materials, which resulted in an order for the J. M. asbestos-sponge felt pipe and boiler covering.

The efficiency of this pipe covering is accounted for by the millions of "dead air" cells it contains. Recent tests made by Prof. C. L. Norton, of the Massachusetts Institute of Technology, show that the yearly cost of maintaining 100 sq.ft. of pipe at 100 lb. gage pressure is, for bare pipes, $225; for 1-in. molded insulation, $35.90; and for 1-in. J. M. asbestos sponge $25.40.

This covering is made of many layers of thin felt composed of pure asbestos fiber and finely ground sponge. It is tough and flexible so that vibration, moisture, heat or rough usage will not cause it to break, crack, crumble or lose its insulating efficiency. It is fireproof and can be removed and replaced an indefinite number of times without deterioration.

The Largest Inland-Water Steamship—The "Seeandbee," a new side-wheel passenger steamer placed in service this summer between Cleveland and Buffalo, is the largest side-wheel steamer in existence. Five hundred feet over all, she has an extreme beam over the guards of 98.6 and a depth of hull at the stem of 30 ft. 4 in. The "Seeandbee" has six decks, and provides over 500 staterooms. She is driven by engines of 12,000 hp. at a speed of 22 miles an hour.

ELECTRICAL DEPARTMENT

The Induction Motor—IV

By F. A. Annett

Starting Devices for Squirrel-Cage Motors

Although the wound-rotor polyphase induction motor has the most satisfactory starting properties of any type, developing about 100 per cent. starting torque for 100 per cent. full-load starting current, other starting torques being approximate to the current taken until maximum starting torque is obtained, and can readily be used for variable-speed service. It is, nevertheless, inferior to the squirrel-cage type in every other respect. The cost is higher, the construction not so rugged, the efficiency, power factor, and pull-out point are lower and the motor itself requires more attention than the squirrel-cage type. For these reasons probably 75 per cent. of the polyphase motors in use today are of the squirrel-cage type.

One of the greatest objections to the squirrel-cage motor is the large current at low power factor taken from the line at starting. This heavy starting current is very objectionable for several reasons. If the motor is started on a lighting circuit the heavy starting current causes the lamps to flicker and if the motor is started very often this flickering of the lamps becomes very objectionable. The excessive current taken at starting may overload the prime mover and generator supplying the power or the

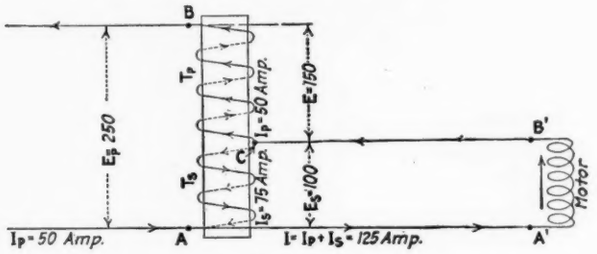


FIG. 32

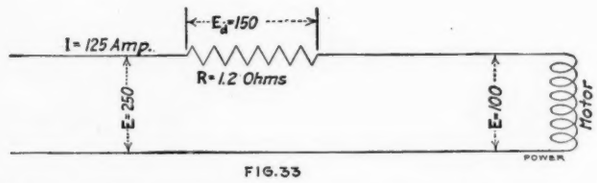


FIG. 33

Figs. 32 and 33. Representing Diagrammatically an Auto-Transformer and a Starting Resistance

transformers from which the motor is supplied, or the starting current may represent a large percentage of the total power transmitted in the feeder. This may cause an excessive drop in voltage which may affect other devices supplied from the same feeder. In some cases the heavy lagging current may cause synchronous devices on the same system to hunt.

To reduce the starting current and improve the starting torque of squirrel-cage motors various devices are used such as auto-transformers, rheostats and special starting coils in the stator windings, the latter will be explained later. Perhaps the most common is the auto-transformer.

In sizes up to 5-hp. induction motors are usually started by connecting them direct to the line. In sizes of 5 hp. and above an auto-transformer or starting rheostat is used. Some prefer the rheostat for starting small motors, and the auto-transformer for large ones.

An auto-transformer has but one winding for both primary and secondary. This type of construction reduces the amount of copper used, depending upon the ratio of transformation. Fig. 32 represents an auto-transformer diagrammatically. Let it be assumed that the line pressure is 250 volts and the transformer coil has 150 turns with a 100-volt tap taken off and as this tap will be in a ratio of the primary volts to the secondary volts, the turns in the secondary can be expressed in the proportion, Primary volts : secondary volts = total turns : secondary turns, that is, as 250 : 100 = 150 : secondary turns, or

$$Secondary\ turns = \frac{100 \times 150}{250} = 60$$

Therefore, the 100-volt tap will include 60 turns of the coil and the voltage will be as indicated.

Assume that the current taken from the line by the motor is 50 amp. This current at a given instant will flow from terminal A of the line to terminal A' of the motor; from terminal B' of the motor to the low-voltage tap C of the auto-transformer, through section BC of the auto-transformer to terminal B, as shown by the arrows. The current flowing through section BC of the coil sets up a magnetic flux which induces an e.m.f. of 100 volts in section AC opposite to the e.m.f. in section BC so that the current in AC will flow opposite to the current in BC and will be in an inverse proportion to the number of turns in each section of the coil, for theoretically the ampere turns (T_p) in the primary coil must be equal to the ampere turns (T_s) in the secondary coil; hence the inverse proportion

$$T_s : T_p = I_p : I_s$$

Therefore,

$$I_s = \frac{T_p \times I_p}{T_s} = \frac{90 \times 50}{60} = 75\ amp.$$

which will flow in the direction as shown by the arrow heads and combines with the primary current so there is flowing through the motor a current of

$$I_p + I_s = 50 + 75 = 125\ amp.$$

although the generator is only required to supply 50 amp.

If a resistance was used to reduce the voltage instead of an auto-transformer, for the motor to have the same starting torque it would have to receive 125 amp. from the line at 100 volts impressed at the motor terminals. To get this condition a resistance that will cause a drop of 150 volts with a current density of 125 amp. must be connected in series with the motor. This resistance R

would equal the voltage drop divided by the current, or

$$R = \frac{150}{125} = 1.2 \text{ ohms}$$

This condition is shown in Fig. 33, and the generator has to supply 125 amp. to the motor instead of 50 amp. as

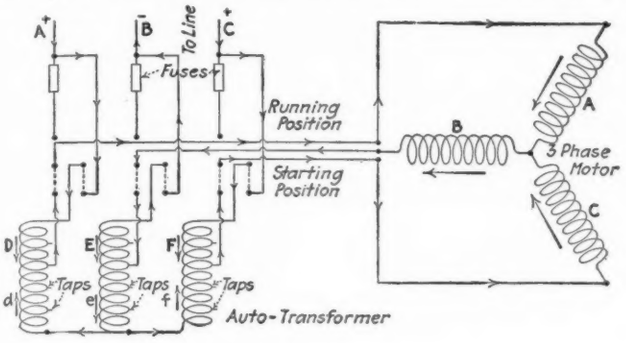


FIG. 34

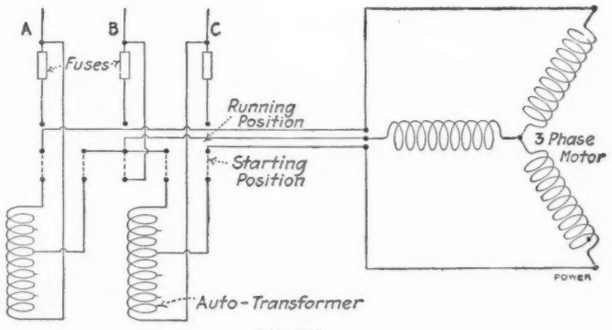


FIG. 35

FIGS. 34 AND 35. STARTING COMPENSATORS

when an auto-transformer was used. In the case of the resistance the watts loss equals the voltage drop across the resistance multiplied by the current, or

$$150 \times 125 = 18{,}750 \text{ watts}$$

The total power supplied by the generator when starting with a resistance is

$$EI = 250 \times 125 = 31{,}250 \text{ watts}$$

the difference between this and the watts lost in the resistance being the power supplied to the motor, or

$$31{,}250 - 18{,}750 = 12{,}500 \text{ watts}$$

With the auto-transformer all the energy supplied by the generator (except a small loss in the coils of the auto-transformer) was used in starting the motor, that is,

$$EI = 250 \times 50 = 12{,}500 \text{ watts}$$

From the foregoing it would seem that an auto-transformer has much superior starting properties to that of a rheostat, and this would be true if the power factor at starting were unity. However, the power factor is very low, and as the drop in the line is largely due to the wattless component of the current and not the power component, with either type of starter the wattless component is about the same. Therefore the line disturbance would be about the same in one case as in the other. The power component produces some drop and this is greater with the resistance type of starter, but is again offset by the lagging current required to set up the flux in the transformer core.

One feature that any starting device should possess to be entirely satisfactory is automatic adjustment of the voltage at the motor as it comes up to speed, and in this feature the resistance type of starter is superior. At the instant of starting the motor takes a maximum current from the line; this causes a maximum drop across the starting resistance, and as the motor speeds up it generates a counter e.m.f. which increases with the speed and the current decreases. As the current decreases the voltage drop across the resistance decreases and increases across the motor terminal. This will be made clear by again referring to Fig. 33. If the condition at the instant of starting is as shown with a starting current of 125 amp., the drop across the starting resistance is 150 volts with 100 volts impressed on the motor terminals. If after the motor has come up to speed the current decreases to 50 amp., the voltage drop (Ed) across the resistance will equal the resistance (R) multiplied by the current (I) or

$$Ed = RI = 1.2 \times 50 = 60 \text{ volts}$$

The voltage impressed upon the motor terminals will

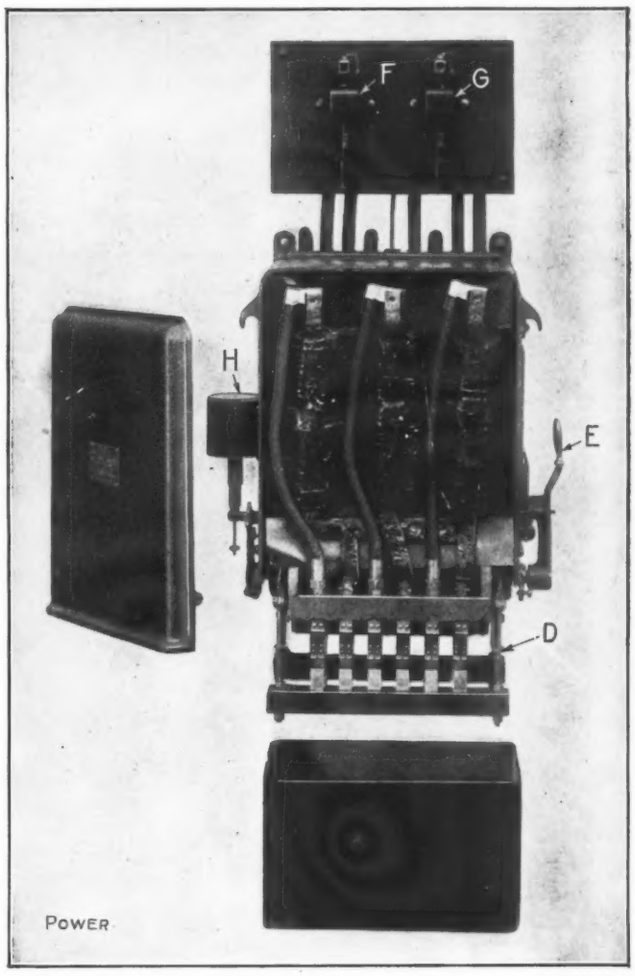


FIG. 36. G. E. COMPENSATOR WITH COVER REMOVED

equal the difference between the line voltage (E) and the drop across the resistance, or

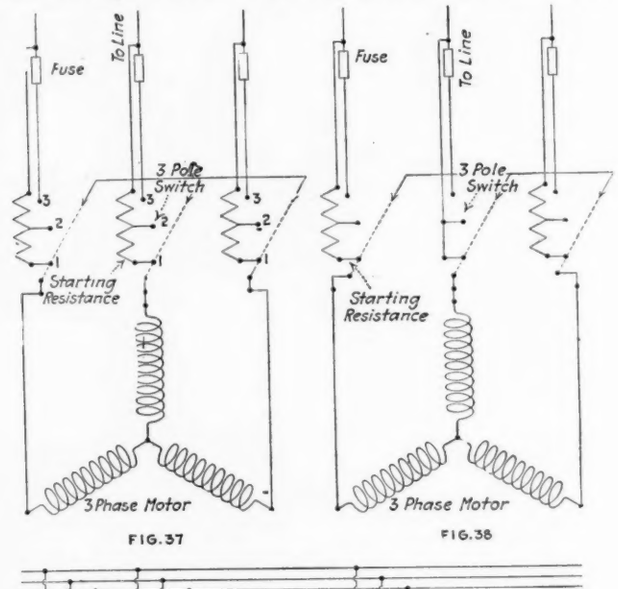
$$E - Ed = 250 - 60 = 190 \text{ volts}$$

Therefore, the voltage has automatically increased at the motor terminals from 100 to 190; this is not possible with an auto-transformer, for the secondary voltage is fixed by the ratio of the primary turns to the secondary turns. Moreover, the resistance type of starter can be readily constructed with a number of intermediate steps. This

means that the voltage can be gradually raised at the motor and when the latter is thrown directly on the line the voltage change will not be so great, consequently, the current taken from the line will not be so great with its corresponding drop in line voltage.

The resistance starter is much cheaper than the auto-transformer, which is one reason for its use with small motors. As regards the power taken from the line at starting the auto-transformer is distinctly superior to the resistance type; hence a large percentage of squirrel-cage motors are started by this means, the resistance type being limited usually to sizes below 25 hp.

For starting two-phase motors two single-phase auto-transformers are used, one connected across each phase, and for starting three-phase motors two types of compensators are used, one using a three-phase auto-transformer with the three coils connected in star. Fig. 34 shows such a starting compensator and motor diagrammatically. At starting the switch is thrown to the position shown by the dotted lines. This connects the motor through the auto-transformer to the line beyond the fuses, which would be blown by the heavy starting current if left in the circuit. Assuming an instant when the line polarity is as indicated, that is, A and C are positive and B negative, then when the switch is closed current will flow from A and C through sections D and F of the auto-transformer through the motor winding and back through section E of the auto-transformer to the middle terminal of the line B, as shown by the arrows. This current flowing through sections D, E and F of the auto-transformer induces an e.m.f. in sections d, e, and f, opposite to the e.m.f. in sections D, E and F; therefore, a secondary current, having the direction shown will combine with the primary current and flow through the motor. This is identical to the conditions represented in Fig. 32, only in this case three transformers are used instead of one. After the motor comes up to speed the switch is thrown over in the opposite position and the motor is connected direct to the line through the fuses.



FIGS. 37 AND 38. BALANCED AND UNBALANCED RHEOSTATS
FIG. 39. ARRANGEMENT FOR STARTING SEVERAL MOTORS FROM ONE COMPENSATOR

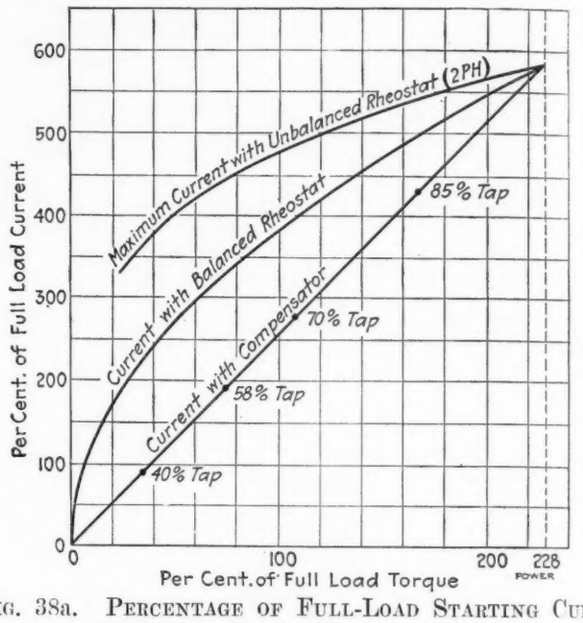


FIG. 38a. PERCENTAGE OF FULL-LOAD STARTING CURRENT REQUIRED AND CORRESPONDING TORQUE*

The second type of starting compensator used by several manufacturers to start three-phase motors is one that employs two auto-transformers connected in open delta. This type has the advantage that it can be used for starting either three-phase or two-phase motors. Fig. 35 shows such a starting compensator connected to a three-phase motor, the action being similar to that of Fig. 34.

Fig. 36 shows a G. E. compensator with the cover removed to show the various parts; in the center are the three coils of the three-phase auto-transformers. The double-throw switch D is operated by the handle E which is interlocking and cannot be thrown to the running position until first thrown to the starting position. Overload relays F and G protect the motor from overloads and may be replaced by fuses; H is a no-voltage release coil which when the line voltage fails releases the starting switch D and handle E and they come back to the off position so that the motor will not be started when the power comes back on the line, except by an attendant. The oil tank in which the switch D is immersed is shown at the bottom.

A motor that has to start under a heavy load will require a much higher voltage than one starting under light load and taps are usually brought out so that about 35, 50, 65 or 85 per cent. of the line voltage may be impressed on the motor terminals. With some starters, employing a drum switch immersed in oil, two or more voltage taps are brought into action in steps.

Two types of rheostats are used for starting three-phase squirrel-cage motors—the balanced and the unbalanced types, the former employs three resistances, one connected in each leg of the circuit, and usually arranged so that resistance can be cut out in equal steps, as shown diagrammatically in Fig. 37. The connections are made so that the fuses are out of circuit as with the auto-

*By courtesy of the "General Electric Review."

transformer at starting. For starting, the switch is thrown to position (1), which connects the motor to the line with all the resistance in series; as the motor speeds up the switch is thrown to position (2), this cuts out one section of the resistance in each leg of the circuit, causing a further increase in speed. The switch is next thrown to position (3), which connects the motor direct to the line through the fuses. Contacts (1) and (2) are arranged so that they are out of circuit when the switch is in the running position.

The unbalanced type has two resistances, one in each of two legs of the circuit, as shown diagrammatically in Fig. 38. These are arranged so that they can be cut out of the circuit similar to Fig. 37. Although this type costs less than the balanced type the starting current is much larger for a given starting torque and cannot be recommended except in cases where cost is of primary importance. The curves in Fig. 38a show the percentage of full-load starting current required by a 20-hp. motor in the three different cases in terms of the required starting torque. From the curves it will be seen that to obtain full-load torque with the compensator the starting current is 260 per cent., and with an unbalanced rheostat 380 per cent., and with an unbalanced rheostat 475 per cent.

Any size of squirrel-cage motor within the capacity of an auto-transformer may be satisfactorily started from it, as the voltage applied at the motor terminals at starting is fixed by the ratio of the transformer and is, therefore, theoretically the same for a large motor as for a small one. It is general practice to furnish each motor with its own starting device but is sometimes convenient to arrange to start several motors from the same starting compensator. A scheme for doing this is shown in Fig. 39. In addition to the starting compensator (which must be of a capacity equal to that of the largest motor started by it) a three-pole double-throw switch must be provided for each motor. When the switch is thrown to the lower position the motor is connected to the line through the starting compensators, after it has come up to speed the three-pole switch is thrown to the up position, thus connecting the motor directly to the line. The auto-transformer is then brought back to the off position ready to start up any other motor desired.

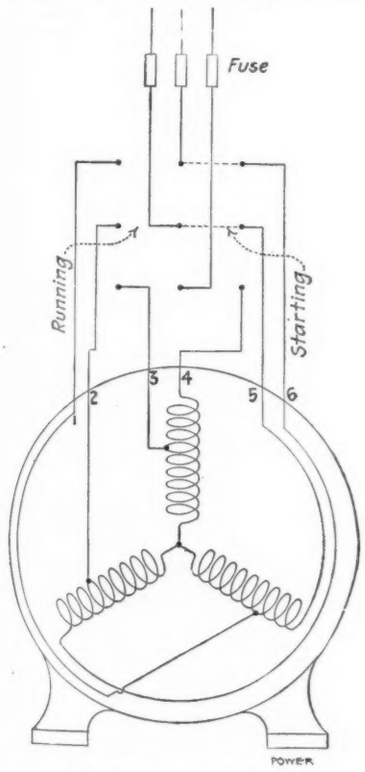


FIG. 40. SHOWING ADDITIONAL TURNS IN STATOR WINDING FOR STARTING

A squirrel-cage motor may be provided with additional turns in the stator windings for starting. The Richmond Electric Co. builds a motor of this type, as shown diagrammatically in Fig. 40. When the three-pole switch is thrown to the starting position all the turns in the windings are in series after the motor has come up to speed.

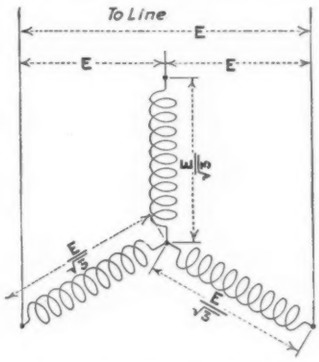


FIG. 41. THREE-PHASE STAR-CONNECTED WINDING

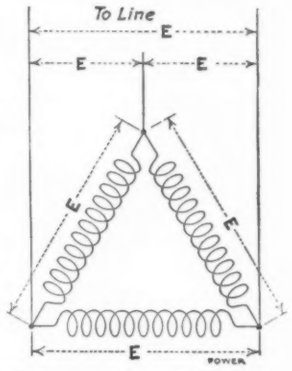


FIG. 42. THREE-PHASE DELTA-CONNECTED WINDING

The switch is then thrown over to the running position and part of the stator winding is cut out. To provide room for the starting coils the stator core and frame have to be made larger than otherwise.

Another method used in starting three-phase squirrel-cage motors is the star-delta method used by the Crocker-Wheeler Co. for starting motors of less than 30 hp. At starting, the three stator windings are connected in star, as shown in Fig. 41. The voltage across each winding is equal to the line voltage (E) divided by the $\sqrt{3}$ or about 57 per cent. of the line voltage; this is usually sufficient to start the motor under most conditions. When the motor comes up to speed the switch is thrown to the running position, and the windings are connected in delta, as in Fig. 42; this applies full-line voltage across each winding.

It should be mentioned that in some cases it is possible to bring out low-voltage taps from the neutral of the transformers supplying the power and by means of a three-pole double-throw switch 50 per cent. line voltage can be obtained for starting. This requires two sets of wires being run from the transformers to the starting switch at the motor. If the motor is some distance away from the transformers the cost of the additional conductors may be equal to or exceed that of a starting device.

The Largest Wood-Stave Pipe—The Northwestern Electric Co., Portland, Ore., has recently built for the conveyance of water what is probably the largest wood-stave pipe yet constructed. It is 13½ ft. in diameter, one mile in length, and it serves as the flow line from the dam to forebay. According to details given in the "Engineering News," there are ninety-four 4-in. staves around the circumference, the normal length of which is 18 ft.

The construction of this wood pipe line called for over 1,600,000 ft. board measure of Douglas fir, consisting of 1,000,000 ft. in the pipe proper, 476,000 ft. in the cradle and 210,000 in the mud sills. The staves were laid without tongue or groove, there being a steel dowel plate in one end of each stave to make tight the butt joints. The pipe was laid upon a bed of solid ground and, to stiffen it against distortion, it was carried in supporting cradles which were spaced about 4½ ft. apart on tangents, the saddles being carefully cut to the desired shape.

GAS POWER DEPARTMENT

Gas Engines vs. Steam for Pumping

Comparison on a commercial basis between a suction-gas-producer pumping-engine plant and a steam-engine plant operating under similar conditions is afforded in a paper by J. E. Gibson and S. H. Wright which was read before the Engineers Club, of Philadelphia, and appears in the *Proceedings* for October.

The gas plant belongs to the Delaware Water Co. and is situated at the head of tide water on Christiana Creek.

TABLE I. FIXED CHARGES

	Gas Plant	Steam Plant
Management	$ 200	$ 200
Superintendence	920	920
Depreciation	1694	1,987
Sinking fund	1043	1,297
Interest	4095	6,491
Insurance	76	250
Taxes	263	327
Total	$8291	$11,472

It consists of two complete producer units rated at 110 hp. each and two 13x12-in., single-acting, three-cylinder vertical gas engines of 89 b.hp., each direct connected to a 13x15-in., single-acting triplex pump. The engines run at 265 r.p.m. and the pumps, through a 5 to 1 reduction gear, at 44 r.p.m., at which speed each has a capacity of 1,640,000 gal. per 24 hr.

The cost of the plant was as follows:

Building and property	$38,750.00
Producers and engines complete, including auxiliaries	13,000.00
Pumps complete	7,250.00
Piping, air chambers, etc.	4,500.00
Total	$63,500.00
Cost of plant per brake horsepower	$392.00
Cost of plant per million gallons capacity per 24 hr.	19,250.00

A high grade of anthracite pea coal is used, costing $5.10 per long ton delivered into the storage bins.

Steam Pumping Plant

The steam pumping plant belongs to the Octoraro Water Co., and is located on the Octoraro Creek, near Quarryville, Penn. It consists of three 100-hp. return-tubular boilers supplying steam to two horizontal, cross-compound condensing Corliss pumping engines, having 18 and 32 by 30-in. steam ends and 10x30-in. water ends delivering at a pressure of 150 lb. These engines run at 55 to 60 r.p.m. and are rated at three million gallons capacity. The cost of this plant was as follows:

COST OF STEAM PLANT

Building and land	$37,875.00
Boilers, engines, piping and auxiliaries	39,850.00
Total	$77,725.00
Cost of plant per brake horsepower, allowing 10 per cent. for engine friction	$190.00
Cost of plant per million gallons capacity per 24 hr.	$12,100.00

The fuel used is high-grade bituminous, costing $4.40 per long ton delivered at the plant.

TABLE II. OPERATING CHARGES

Item	1908 Plant		1909 Plant		1910 Plant		1911 Plant		1912 Plant	
	Gas	Steam	Gas	Steam	Gas	Steam	Gas	Steam	Gas	Steam
Fuel	$609.22	$3497.78	$641.51	$3953.50	$1173.58	$4098.81	$1474.40	$4167.30	$1796.35	$4418.07
Oil, waste and packing	180.62	182.38	195.58	168.90	333.33	128.93	227.57	201.88	200.64	202.70
Building and machinery repairs	100.64	103.83	*280.07	14.00	†418.73	245.97	251.06	542.87	‡416.19	603.83
Pumping-station wages	1501.67	2529.60	1853.06	2412.15	2276.03	2309.88	2518.27	2180.00	2507.89	2382.82
Miscellaneous expenses	75.09	192.59	133.75	107.09	143.18	81.11	183.90	146.03	274.81	197.30
Total per annum	$2467.24	$6506.18	$3103.97	$6655.64	$4344.85	$6864.70	$4655.20	$7238.08	$5195.88	$7804.72

* Includes the replacing of spiral riveted purge pipes on producers, with cast-iron pipe.
† Includes spare parts for engines, such as inlet and exhaust valves, piston rings and piston, etc.
‡ Includes compromise settlement of claim for damaged castings that developed in producer in 1908, before the plant was finally accepted.

TABLE III. COMBINED FIXED AND OPERATING CHARGES

Item	1908 Plant		1909 Plant		1910 Plant		1911 Plant		1912 Plant	
	Gas	Steam	Gas	Steam	Gas	Steam	Gas	Steam	Gas	Steam
Operating expenses	$2,467.24	$6,506.18	$3,103.97	$6,655.64	$4,344.85	$6,864.70	$4,655.20	$7,238.08	$5,195.88	$7,804.72
Fixed and overhead charges	8,291.00	11,472.00	8,291.00	11,472.00	8,291.00	11,472.00	8,291.00	11,472.00	8,291.00	11,472.00
Total yearly cost	$10,758.24	$17,978.18	$11,394.97	$18,127.64	$12,635.85	$18,710.71	$12,946.20	$18,710.08	$13,486.88	$19,276.72

TABLE IV. COST OF PUMPING ONE MILLION GALLONS 100 FT. HIGH

	Unit per Million Gallons Actually Pumped 100 Ft. High		1908		1909		1910		1911		1912	
			Gas	Steam	Gas	Steam	Gas	Steam	Gas	Steam	Gas	Steam
Fixed Charges	Management	1	$0.995	$0.491	$0.589	$0.482	$0.318	$0.415	$0.301	$0.407	$0.293	$0.376
	Superintendence	2	4.590	2.265	2.715	2.215	1.465	1.908	1.381	1.875	1.345	1.741
	Depreciation	3	8.440	4.985	5.000	4.790	2.695	4.120	2.552	4.050	2.480	3.755
	Sinking fund	4	5.200	3.180	3.080	3.120	1.658	2.685	1.569	2.645	1.522	2.498
	Interest	5	20.400	15.970	12.080	15.620	6.500	13.440	6.150	13.230	5.980	12.270
	Insurance	6	0.379	0.615	0.224	0.602	0.121	0.519	0.114	0.509	0.111	0.473
	Taxes	7	1.313	0.803	0.787	0.788	0.418	0.693	0.396	0.666	0.400	0.618
	Total cost per annum	8	$41.317	$28.219	$24.475	$27.617	$13.175	$23.780	$12.463	$23.382	$12.131	$21.731
Operating Charges	Fuel	9	$2.615	$2.410	$1.441	$2.698	$1.291	$2.425	$1.505	$2.510	$1.860	$2.305
	Oil, waste and packing	10	0.775	0.126	0.439	0.115	0.366	0.076	0.232	0.126	0.208	0.106
	Pumping-station wages	11	7.490	6.210	5.470	5.825	3.615	4.790	3.787	4.450	3.670	4.520
	Machinery repairs and building	12	0.432	0.072	0.631	0.0095	0.461	0.146	0.256	0.327	0.431	0.315
	Miscellaneous expenses	13	0.322	0.133	0.300	0.0735	0.157	0.048	0.188	0.088	0.285	0.103
	Total cost per annum	14	$11.634	$8.951	$8.281	$8.721	$5.890	$7.485	$5.968	$7.501	$6.454	$7.349
	Total of Operating and Fixed charges	15	$52.951	$37.170	$32.756	$36.338	$19.065	$31.265	$18.431	$30.883	$18.585	$29.080
		16	Average cost of pumping 1 million gal. 100 ft. high—gas									$28.36
		17	Average cost of pumping 1 million gal. 100 ft. high—steam									32.95

The overhead charges for the two plants are given in Table 1. The management and superintendence are taken the same for both cases, but owing to the larger capacity, and hence greater first cost, of the steam plant, its total fixed charges are greater. In figuring the depreciation, however, the life of the gas-engine plant was taken as 15 years as against 20 years for the steam-engine plant. This does not apply to the buildings which were in both cases considered to have a 35-year life.

The operating charges for the past five years for both plants are given in Table 2 and the combined operating and fixed charges in Table 3. The fixed, operating and total costs reduced to a basis of pumping one million gallons 100 ft. high are given in Table 4.

The items on lines 1 to 7 inclusive and 11 were obtained by dividing the annual cost for those items by the actual number of million gallons pumped for the year, as these charges were independent of the pumping head.

From Table 4 it will be seen that for 1908 the total cost for operating the gas plant was considerably greater than the steam plant. This was because for the first year only one pump was operated for only part of the day. The consumption has now reached the point where it is found advisable to operate one pump continuously and the second pump several hours each day. In justice to the steam plant it should be noted that, owing to its larger capacity, its load factor is less than the gas plant.

Mean Effective Pressures

In the issue of Oct. 14, under the heading "Horsepower of Small Gas Engines," it is stated that the full-load horsepower may be estimated by assuming a mean effective pressure. This is true, but it might be well to go into detail and tell how this assumption is made. I have, therefore, added several well known methods of determining values of mean effective pressure.

Grover's Method

This was determined by examining a large number of indicator diagrams, neglecting the effect of the kind of fuel or the quality of the mixture. By this method, M.E.P. $= 2C - 0.01C^2$, where C is the compression pressure in pounds per square inch absolute. According to this, the mean effective pressure increases up to a maximum at 100 pounds per square inch gage, beyond which it decreases, giving results which are of practically no use.

Moss' Method (Power, July, 1906)

Here the author not only considers the kind of fuel, but also considers the size of the engine. The mean effective pressure will increase with the engine size on account of the relatively less cooling loss in large than in small engines; rich mixtures may also be expected to give higher mean effective pressures. Moss' table for values of mean effective pressure are as follows:

MEAN EFFECTIVE PRESSURES, POUNDS PER SQUARE INCH.

Compression Pressure Lb. per Sq.In. Gage	Probable Clearance as Per Cent. of Displacement Volume	Approximate Brake Horsepower of Engine						
		5	10	25	50	100	200	500
50	40	60	65	70	75	...	...	...
60	35	65	70	75	80	...	...	...
70	30	70	75	80	85	85	90	95
80	28	70	75	85	90	90	95	100
90	26	..	..	90	95	95	100	105
100	24	..	..	95	95	100	100	110
110	22	..	..	95	95	100	100	110
120	20	..	..	..	..	100	100	110

In the foregoing table, only four-stroke-cycle engines are considered and the fuel is assumed to be average natural gas or illuminating gas. If some other fuel is used, a correction factor should be supplied from the following table:

RATIOS OF HEAT OF COMBUSTION PER CUBIC FOOT OF PERFECT MIXTURE TO THE VALUE FOR AVERAGE NATURAL GAS OR ILLUMINATING GAS

Fuel	Correction Factor
Oil gas	1.00
Water gas (uncarbureted)	1.00
Coke-oven gas	0.93
Air gas (Siemens producer gas)	0.79
Water gas (carbureted)	1.05
Anthracite producer gas	0.80
Bituminous producer gas	0.87
Blast-furnace gas	0.67
Acetyline gas	1.28
Gasolene	1.12
Kerosene	0.90

Güldner's Method

This is based upon the following two well known facts: (1) Power depends upon the volume of mixture handled in a unit time. (2) Power depends upon the thermal efficiency with which the engine can handle the volume. The first involves cylinder dimensions and revolutions per minute, and fixing any two determines the third. The only assumption made is that of volumetric efficiency, and due to such large amounts of experimental data being available, no great error can be made regarding this point; the same being true for thermal efficiency and fuel characteristics. Güldner's formula is

$$B.hp. = \frac{n \times e \times l \times H \times d^3 \times E_v}{108 \times L}$$

Where

n = Revolutions per minute;
e = Thermal efficiency;
l = Stroke in feet;
H = Heat value of fuel in B.t.u.;
d = Piston diameter in feet;
E_v = Volumetric efficiency of suction stroke;
L = Cubic feet of air required for one cubic foot of gas fuel.

To L, e and E_v values must be assigned, and with such an abundance of practical data available, no difficulty should be experienced in that direction.

A. L. A. M. Formula

B.hp. $= d^2 N/2.5$, where d is the cylinder diameter in inches and N is the number of cylinders. Since the term 2.5 results from the contraction of several arbitrarily assumed factors, the formula is of no use whatever as far as design is concerned.

Rice's Formula

$$B.h.p. = \frac{d^2 \times l \times N \times n}{14{,}000}\left(0.48\,\frac{1}{10\,Cl}\right)$$

where

d = Cylinder diameter in inches;
l = Stroke in inches;
N = Number of cylinders;
n = Revolutions per minute;
Cl = Clearance in terms of piston displacement.

By using the foregoing formulas to solve the same problem, it will be found that the results vary so as to make it difficult to predict with accuracy the values of mean effective pressure and horsepower.

M. A. Ticker.

Newburgh, N. Y.

HEATING AND VENTILATION

Special Ward Heating and Ventilation

By H. S. Knowlton

The Peter Bent Brigham Hospital, a group of fifteen new buildings near the Harvard Medical School, Boston, is one of the most modern institutions of its kind in the country. The facility with which patients in bed can be rolled out of doors, the provision for natural lighting, sanitation, steam and hot-water systems, and floor-warming coils under certain ward rooms are interesting features. The heating and ventilation plant was designed by Densmore & LeClear, mechanical engineers, Boston, and in the following paragraphs are given the principal features of heating and ventilation employed in a typical ward building.

Heating and power service are supplied from the adjacent plant of the Harvard Medical School through an 8x8-ft. reinforced-concrete tunnel. A typical ward building accommodates 40 patients. There are three general wards, the octagonal room *A* and the ward *B* on the first floor, and ward *E* on the second, with 14, 8 and 12 beds respectively, and five special wards with one and two beds each. The general arrangement of the heating and ventilating system is shown in Figs. 1 and 2. The heating is mainly by hot-water radiators connected to a two-pipe under-fed system. Wards *A*, *B* and *E* are heated and ventilated, and the smaller wards are ventilated by the introduction of fresh air on the plenum system. Diet kitchens, duty rooms and other places from which odors may come are ventilated by the use of exhaust fans. Hot-water heating was selected on account of its quietness of operation and uniformity of temperature control secured. Fig. 1 shows the general arrangement of heater, screen and fan rooms in the basement of a typical ward.

The cold air entering the heater room passes through the first two groups of a stack of 1134 sq.ft. of heating surface, the groups being valved separately for partial regulation. A portion of the air flows through the two remaining groups, and the remainder is bypassed through a mixing damper, whence it passes to the upper portion

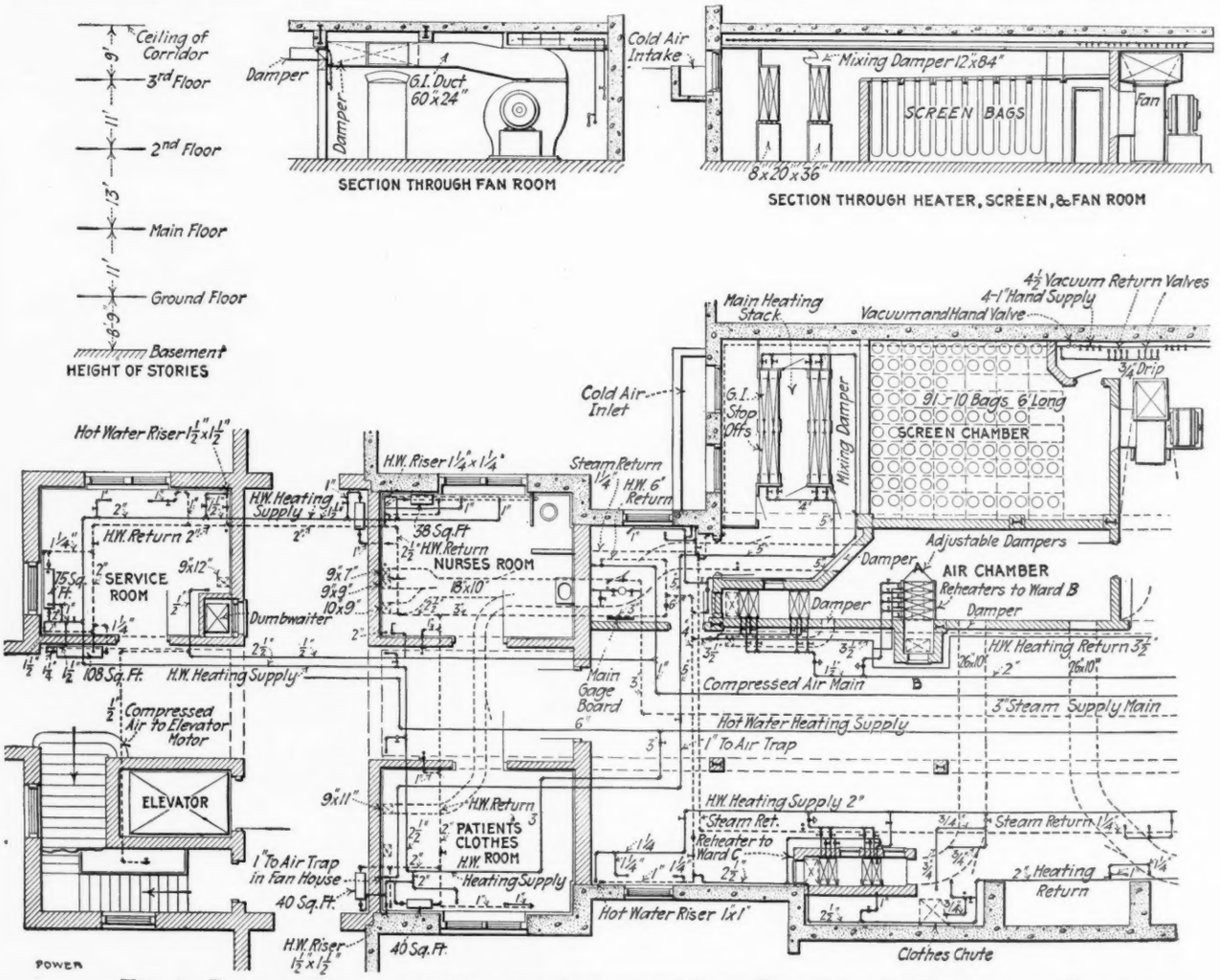


Fig. 1. Plan of Piping and General Arrangement of Heating and Ventilating System

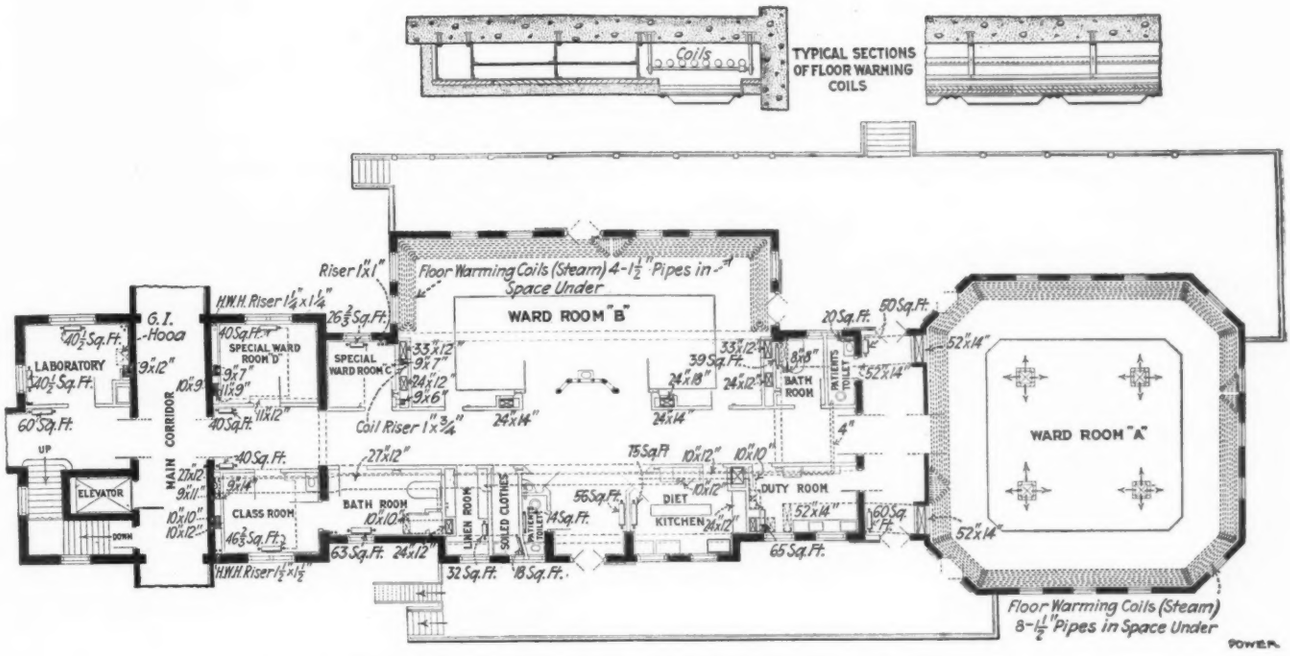
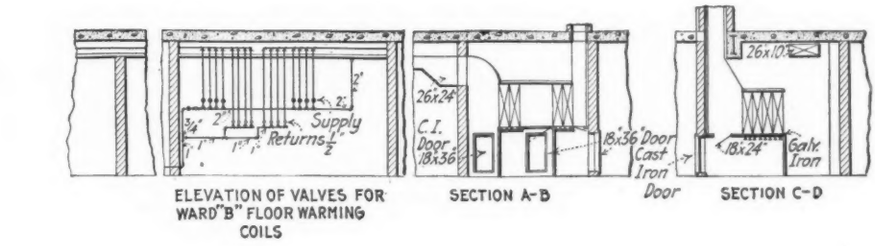
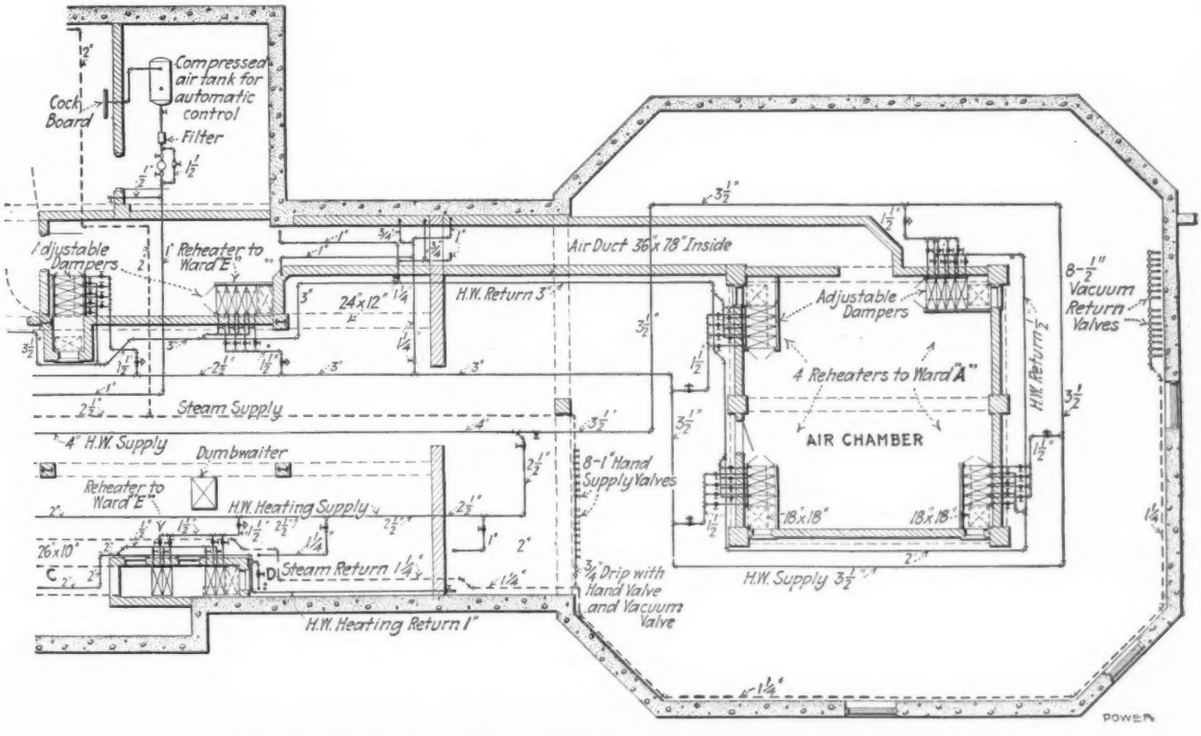


FIG. 2. FIRST-FLOOR PLAN OF PETER BENT BRIGHAM HOSPITAL





A CONTINUATION OF FIG. 1, SHOWING SOUTH HALF OF BUILDING

of the screen chamber where it is drawn through dust bags and enters a No. 9 Sturtevant multivane fan with a capacity of 17,100 cu.ft. per min., driven by a 6-hp. motor with a speed range of from 171 to 284 r.p.m. From the fan room the air is forced through a galvanized-iron duct branching into two air chambers, one on either side of the entrance to the fan room. An adjustable damper is located at the bifurcation. One of the air chambers is connected by a 36x78-in. horizontal masonry duct with a square air chamber under ward *A*. At each of the four corners of the latter is a reheater containing 215 sq.ft. of heating surface, giving a total of 860 sq.ft. of reheating surface for the octagonal ward. There are also four similar reheaters, two in either air chamber adjacent to the fan and heater rooms, two each serving wards *B* and *E*. Ward *E* has two additional reheaters, each containing 215 sq.ft. of surface, located at the west wall of the basement, supplied by 26x10-in. ducts.

A system of galvanized-iron ducts connecting the air chamber adjacent to the heater room with riser ducts supplies a classroom, and special ward rooms at the northern end of the building. Adjustable dampers are installed at the branches of the ducts and at the lower ends of the riser ducts leading from the air chamber. Fresh air enters ward room *A* through four 18x24-in. registers placed in the sides of square concrete supports about 3 ft. in height, spaced at the four corners of a square in the center of the room above the reheaters on the floor below. This arrangement gives an even distribution of air throughout the ward. Two 52x18-in. outlets are located near the ceiling in the partition wall, one on either side of the doorway.

Ward *B*, situated on the east side of the corridor in the central portion of the building, is served by two 24x14-in. inlet ducts in the corridor wall, and two 33x12-in. outlet ducts in the wall at either end of the room. Ward *E*, occupying the full width of the southern end of the building on the second floor, is supplied by four 24x12-in. riser ducts placed in the end walls near the corners. The exhaust ducts from wards *A*, *B* and *E* are carried into four vents fitted with an aspirating steam coil of 15 sq.ft. of surface, discharging into the open air above the roof over ward *E*.

Monitors over wards *A* and *E* ventilate the rooms when the indirect heating plant is not in use. The ventilation system provides for five changes of air per hour in the classroom and all the ward rooms except *A* and *E*, which are supplied with 4.53 and 5.86 changes per hour respectively. The above figures, in terms of cubic feet per hour per patient, give 12,400 for ward *A* and 11,000 for ward *B*. All toilets are ventilated at the rate of 1500 cu.ft. per hr. per fixture. Inlet and duct velocities are 6 and 5 ft. per sec., respectively.

Steam coils, as shown in Fig. 2, are placed in a dead space under the floors around the outsides of ward rooms *A* and *B* for the purpose of warming the concrete floors under the beds. Battleship linoleum covers the central portion of these rooms but does not extend under the beds. The coils, consisting of 1½-in. pipes, are placed at one side of an inclosed area about 1 ft. high and 8 ft. wide, and are supported by hangers midway between the top and bottom of the space. Two of the sides are formed by the basement ceiling and the walls, and the other two sides are made of No. 20 galvanized iron supported by 1½x¼-in. hangers and lined with a layer of four-ply, 1-in. thick air-cell blocks with cemented joints. To establish a circulation of warm air, partitions or baffle-plates made of No. 20 galvanized iron have been placed alongside of the coil of pipes attached to 1x1-in. angle irons secured to the hangers. A portion of the casing under the coil of pipes is made removable by covers, in sections, insulated by two layers of air-cell blocks. The galvanized-iron bottom and sides are coated with plaster.

A 6-in., hot-water-heating supply main enters the building from the tunnel branches near the entrance supply the main stack and risers leading to radiators in the rooms at the northern end of the ward. The main runs the length of the basement, encircling the air chamber under ward *A*, delivering to the four reheaters, and returns parallel to itself supplying risers and reheaters in the air chamber near the fan room. It is reduced in size from 6 to 1½ in. at the last reheater. A branch feeds the two ward *E* reheaters, and risers in the central portion on the west side of the basement. The hot-water-heating return line, 1½ in. in diameter, begins at one of the ward *A* reheaters, then runs along the building toward the tunnel, tapping the return drops and the reheaters in the air chambers near the fan room, reaching a maximum diameter of 6 in. A branch of the return main starting on the west side of the basement near the octagonal end, connecting with return drops and reheaters, joins the return main near the entrance to the tunnel; a second branch from the northern end also connects with the main at this point.

A 3-in. pipe taken from the hot-water heating main in the basement of ward *C* building serves as an expansion pipe for the system, and is carried to the roof space adjacent to the fan room, the high point of the entire system, and connects with the bottom of a steel expansion tank 4 ft. in diameter and 9 ft. long. The tank is fitted with a 1¼-in. drawoff, and a 2-in. vapor pipe leading through the roof. A 3-in. overflow pipe with a 2-in. relief valve runs from the top of the tank to the basement and connects with the water drain outside the building. All the other buildings heated by hot water are fitted with a 1-in. pipe leading from a high point in the basement piping to the roof and vented through an inverted Foskett and Bishop trap, discharging air instead of water. Steam at boiler pressure enters the building through a 2-in. line, and is reduced to 5 lb. per sq.in. by a reducing valve which is bypassed. A 2-in. steam main runs along the basement, and branches supply the floor-warming coils for wards *A* and *B*. Hand valves are fitted to the supply end of each pipe comprising the coils, and vacuum valves are installed on the return end of such pipes; also a hand and vacuum valve are fitted on the drip of the horizontal supply pipe feeding the riser pipes of the coils. The Johnson service system of temperature control is used in all wards.

In general throughout the hospital, inlets are located near the ceiling and outlets near the floor. Only a few registers have been installed on account of the difficulty of keeping them free from dust. A grill is placed in each inlet duct, of diagonal 2-in. mesh of No. 10 wire with a channel-iron frame resting on angle-iron supports, and all cold-air openings are grilled. Ducts and flues are designed to avoid friction by the use of sweeps and curves where changes in direction occur. Sturtevant fans are used throughout. The heating contractor was the Cleghorn Co., of Boston.

EDITORIALS

Safety First

The above has been adopted as a slogan by many industries, and various conventions have met and are meeting to promote the idea among manufacturers that it is not only humane but economical to prevent accidents to employees rather than settle for the consequences. Protections of every conceivable nature are being invented to prevent gears, belts, wheels and every part of rapidly moving machinery from causing the accidental injury of those employed in their vicinity.

Notwithstanding the strenuous efforts that are being made to protect machinery, it is said to be proved by statistics, that only twenty per cent. of the industrial accidents can be laid to faulty machinery, the balance being due to carelessness or thoughtlessness on the part of the injured, or the carelessness of some fellow worker. To avoid these accidents, the education of the employee as to how he may protect himself and his fellow worker from the inherent dangers of his occupation, seems to be the only solution. POWER has repeatedly called to the attention of its readers one of the dangers incurred by boiler cleaners, repair men and inspectors who may be required to enter boilers that are connected by pipe lines to other boilers under steam; but the subject is of such importance that it will bear repetition, and especially at a time when a wave of "safety first" seems to be sweeping the land.

Have you ever stopped to think how helpless the man inside the boiler is to protect himself? It is impossible for him to watch the acts of his fellow workers to see if they are likely to jeopardize his safety, and, in fact, he is reduced to one sense, that of hearing, to afford him protection; and receiving a warning by sound is of the most doubtful aid, in avoiding the accidents that are likely to occur. The inspector may be ever so careful and thoroughly examine the valve on every connecting pipe that may become a source of danger, before entering the boiler, only to have all of his precaution set at naught by some meddler or employee who is ignorant of his presence in the plant.

Owners should provide locks for all valves that can admit steam or hot water to a boiler under repair or inspection, and it should not be forgotten that the blowoff valve is one of the most serious menaces to safety, when all blowoff pipes connect to a single main. When a boiler inspector visits a plant for the purpose of making an internal examination of a part of the boilers while the others are under steam, it is not unreasonable for him to expect an attendant to follow his movements while inside the boilers to protect him from possible danger.

While inside one of a battery of extremely hot boilers in the Pittsburgh district one Sunday morning a number of years ago, the writer heard a scuffle on the firing floor followed by a long string of very effective Irish oaths. Coming out of the boiler to learn the cause of the commotion, the Irish engineer was found still menacing a Hungarian laborer who was laying on the coal pile drenched in oil. The engineer had knocked down the Hungarian in the act of "heaving" three gallons of crude oil into the bottom manhole of the boiler just vacated. Had the engineer lacked the ability to think and act at the same time, there would have been registered another fatal boiler accident with the writer playing the rôle of corpse.

If a boiler requires repairs that necessitate the presence of men in it for several days, the pipe connections should be broken at a flange and blanked off. If the boiler is to be entered for only a short time for cleaning or inspecting, the valves should be locked and a sentinel placed on guard while men are inside. If an accident happens under such conditions, the owner or one responsible for taking precautions will have a clear conscience, also a clean record before the coroner.

⁂

Compensating Long Service

A certain operating engineer gave forty-eight years of loyalty and good service to his company. Then his employers, for no given reason, summarily dismissed him. No fault had been found with his ability—he was mentally and physically unimpaired—but the company had entered into no agreement with him beyond the stipulated wages; he was worth to the company just so many dollars and cents; it had profited by the account but concluded to close it. Rather a narrow standard of appreciation, isn't it?

If this engineer had been in the employ of the Pennsylvania R.R., for example, he would have been pensioned, his name placed on its roll of honor, and his half century of service made public. This company knows the exceeding value of loyalty, for its business creed contains an article which says that the company securing the loyalty of its men secures better service; "the creator of loyalty is a public benefactor."

In this company's recent bulletin it is stated that from three men it received one hundred and fifty-four years of loyalty and faithful service. These men were retired with a life pension and placed on the road's roll of honor, which contains four thousand and seven living persons.

Where is the operating engineer's roll of honor, his substantial recognition of a lifetime of service and loyalty?

The industrialists claim that "as the humanistic side of civilization has made progress, we have attained higher ideals regarding industry"; that the mere daily wage of dollars and cents is inadequate recompense. There are many who will take issue with the industrialists in the matter of ideals in our particular field of endeavor. There are those who believe that ninety-eight per cent. of their employees would not even consider the question.

Reward for length of service is no new idea, no experiment; there are many examples in other fields to be had to prove its worth and practical application. Why have the great majority of employers of power-plant en-

gineers seemingly ignored its means to gain added loyalty and length of service?

The comparatively few companies now paying pensions are in a measure pioneers in this work, and it is to be hoped that they will make public their method of procedure. If publicity is given this matter, it may be the means of exciting the interest of employers who would adopt a similar plan were they assured of its success.

A Good Day's Work

What constitutes a good day's work for an engineer? How may the superintendent know when a good day's work has been done?

In the small plant the engineer would doubtless feel that he had earned his pay if he did nothing but keep all apparatus in good shape with a minimum of expense. If he does his own firing, he will also attend to the washing out of the boiler and do many small repair jobs which the superintendent knows nothing about.

Because the engineer can be seen sitting in a chair, apparently doing nothing it does not follow that he is not doing a good day's work. His brain may be busy solving a problem that will produce better plant operation.

The superintendent usually takes it for granted that the engineer who is always engaged in manual labor is a more valuable man than the one who appears to be doing nothing.

One man is engaged in routine work, or shoveling fuel into the furnace, the other is engaged in formulating plans to reduce the necessity of shoveling so much fuel. It requires but little thought to determine which man is doing the better day's work.

In larger power plants the oiler travels over more floor area than the chief engineer. Each does a good day's work if they perform their work to the best of their ability. If the chief engineer neglects doing a duty that should receive attention, and the oiler performs his duties to the best of his ability, he is doing a good day's work, and better than his chief.

It is not always so much what is done as how it is done that counts in the long run. A man may occupy half an hour in making a necessary adjustment and not do another thing all day, and yet have done a good day's work. Neglecting to make the adjustment might result in an expensive accident.

Another man may work hard all day, but neglect the one thing requiring attention and by this neglect permit an accident to occur that would amount in damage to more than he receives for a year's work.

A romping bird dog does not compare with a hunting dog, trained to point out the position of the game, nor does a hurly-burly engineer compare with a thinking engineer in doing a good day's work.

Steam-Turbine Engineering

Ten years ago the following statement appeared in an engineering journal in relation to a two thousand-horsepower turbo-generator: "This was the first American plant where steam-turbine units of large size were installed."

One can scarcely realize that a two thousand-horsepower turbine was ever considered a large unit when compared with the latest development in turbine practice. But ten years ago it is doubtful if even the dreamer of future triumphs had a glimmer of the proportion to which the turbine was to grow. And the end is not in sight for no one seems willing to predict how large in capacity steam turbines will be built. As someone put it, the limit in size and capacity seems, at present, to be governed by the ability to pay the price of construction.

As the turbine has increased in size and capacity the condenser problem has been augmented. One naturally associates a surface condenser with the regulation cast-iron casing. When it comes to making a condenser, capable of handling the steam exhausting from a twenty-five thousand or thirty thousand steam turbine, the size of the unit demands a structure of greater strength than is afforded by cast iron, under ordinary operating conditions. A combination of steel and cast-iron condenser body with water heads has been found advisable in one instance of large-turbine practice.

A condenser capable of condensing the steam from a twenty-five thousand-kilowatt turbine would be equipped with a circulating pump of about forty-two thousand gallons capacity per minute. In fact, the condenser outfit for a large unit would require as much attention, while running, as is given by many engineers to their entire equipment.

With the coming of large turbines the field of the operating engineer has broadened. Ten years ago the engineer in charge of a two thousand-horsepower turbine was considered among the upper class. Today he would be considered of minor importance as a turbine operator. The larger units require men who understand their business. A mistake in operating a small unit means but a comparatively small monetary loss; with one of the monster turbines it may mean a large outlay in repairs beside the loss of output.

The two thousand-horsepower turbine has sunk into insignificance. How long will it be before the thirty-five thousand-kilowatt unit will be regarded as a past mile stone in the march of progress?

It is said that the Pennsylvania R.R. will electrify through to Elizabeth, N. J. This is a step toward the electrification of the entire New York division, and an indication of a general tendency which means more power plants and more chance for the big power-plant engineer.

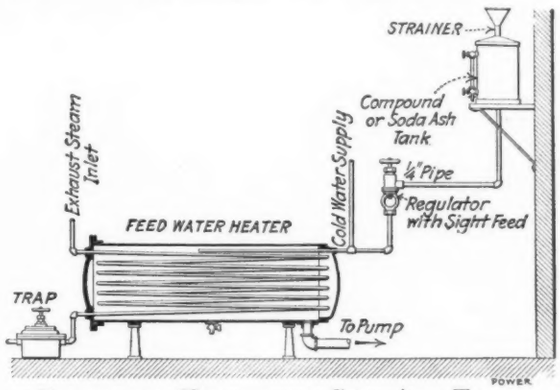
The accidental opening of a valve controlling the flow of water under a head of 450 ft. through a penstock to turbines in the 12,000-hp. Pioneer station of the Utah Light & Railway Co., wrecked the entire plant. While seldom so serious, the mistakes of opening or closing wrong valves, or the right valves at the wrong time are all too common in power plants. It pays to make it a habit to think what the consequences are likely to be before operating a valve.

The American Society of Mechanical Engineers has doubled in membership in the last eight years. So said Secretary Calvin W. Rice at the recent local meeting of the society in New Haven. We predict that it will more than double in half that time if a few more sections of the country take up these local meetings as have Boston, New Haven and Philadelphia, and show a corresponding enthusiasm to that which has been evident in the meetings in the above cities in the last two years.

READERS WITH SOMETHING TO SAY

Soda-Ash for Boiler Waters

The recent article by Mr. Bromley and discussions on the subject of soda-ash calls to my mind a plant that has been using soda-ash for some time with good results. The water is taken from the city mains, and the scale resulting from its use is composed principally of carbonates and sulphates of calcium. All the exhaust drips are returned to the heater through an efficient separator which removes the oil which formerly went through a skimming tank, and, consequently, a great deal of oil went into the boilers. Several kinds of compounds were used which did more damage to the handhole gaskets than it did good to the scale or oil. After the separators were put in very little oil went into the boilers, and soda-ash was substituted for compound with good results.



PIPING FOR HEATER AND SODA-ASH TANK

This is used at the rate of about 1 lb. per 24 hr. per 40 to 50 boiler horsepower, whereas Mr. Bromley recommends about 8 lb. per 100 boiler horsepower or four times as much.* There are no two plants that will require the same treatment, and, for that reason I believe that the conclusions reached by Mr. Bromley might be misleading unless the existing conditions are very carefully studied as well as a chemical analysis of the water made. When it was decided to use soda-ash in the above mentioned plant the matter was figured out along the same line as Mr. Bromley calculated, but after using the soda-ash at that rate for a few weeks it was found that many of the tube caps gaskets were leaking. In fact, the soda-ash oozed out through them and hung like huge icicles on the tube caps. Also it was necessary to increase the amount of cylinder oil used. The compound or soda-ash did not seem to affect the gaskets in the steam line, to any extent, but after the compound had been used several months several leaks showed up in the pipe threads of the flanges and fittings. The manner in which the soda-ash and compound were fed into the boilers is shown in the accompanying sketch, and is so simple that it needs little explanation. The soda-ash is dissolved (the amount required for one day) in about 3 or 4 gal. of hot water and poured into the feeder tank, then the feed valve is set to feed a very small stream into the water entering the feed-water heater. This will feed the chemicals to all boilers in proportion to their rate of working, and will be fed in about 6 to 8 hr. If a greater quantity of water was used it could be made to cover a longer period, but when set to feed by drops it would clog up with sediment.

I believe that the proper amount to use can be better determined by trial than by calculation. If too much is used it will cause foaming, and affect the lubrication of the engines.

J. C. HAWKINS.

Hyattsville, Md.

*[The author of the article referred to stated that 8 lb. of soda-ash would be required as an initial charge to bring the water (5000 lb. for a 100 hp. boiler) up to 3 per cent. (over) normal solution, but not that 8 lb. should be put in daily. To quote from the article: "Unless the boiler primes or there are water leaks or the blowoff is used frequently, little soda ash will be lost from the boiler, and the solution will remain at the proper concentration."—Editor.]

16-Lb. per Hp-Hr. Noncondensing

Asa P. Hyde in a letter published in the Sept. 23 issue of POWER criticizes a test on an 19x21-in. Lentz simple engine, conducted by F. W. Dean, of Boston, expressing his doubts in regard to the correctness of the results obtained. Mr. Hyde bases his reasons on the following statements which were published in the original article on the test which was an extract from Mr. Dean's report to the Erie City Iron Works:

First, steam was so perfectly condensed that only a trifling quantity of vapor escaped, so small that it would not affect the result by a measureable quantity.

Second, the reducing motion was practically correct.

Third, current was absorbed by a water rheostat.

In regard to the first statement it may be said that the intensity of absorption of moisture by the atmosphere depends on the time and the surface exposed to the surrounding atmosphere. The condensed steam was weighed during the test in barrels about 24 in. in diameter, containing approximately 400 lb., and each barrel was filled in about 4½ min. On account of the small opening of the barrels, and the short time it took to fill them, it is out of the question that a quantity could be absorbed by the atmosphere which would have an appreciable bearing on the result. Furthermore, the water was intentionally kept at a comparatively low temperature, about 165 deg., to keep the water in the barrels considerably below the steam temperature.

In regard to the second statement, it can be asserted that there hardly exists a reducing motion that is "absolutely" correct. That is the reason why in the report the word "practically" was used. The reducing motion was carefully examined before the test, and found so nearly correct that it was considered that the stretching of the indicator cord would produce a greater error than the slight fault in the reducing motion. Though the latter could not be termed "absolutely" correct, the error was so slight that it was not measureable.

The water rheostat consisted of a heavy beam to which the different positive and negative electrodes were attached. There were eight pairs of electrodes altogether, which were immerged in the water of eight separate barrels. The amperage could be decreased or increased by raising or lowering the electrodes. A man was stationed right at the barrels in direct communication with the man in charge of the test, and at the direction of the latter, the electrodes were held immerged in the water to such extent as to keep the amperage absolutely constant. The voltage was kept constant by means of a field rheostat which was under the direct supervision of the consulting engineer in charge of the test. All the instruments were carefully calibrated to make sure of their accuracy.

It is plain from the above statements that everything had been done to get accurate figures of the steam consumption of the engine. It can be asserted that conditions were favorable for obtaining correct results, as the steam pressure, superheat and load were practically constant during the test. The fact that the water barrels for weighing the condensed steam were filled up at exactly the same intervals, also emphasizes the correctness of the steam consumption obtained during the test.

Professor Moyer, of the State College of Pennsylvania, was recently in charge of a test on the engine used during the Dean test. The object of this second test was to determine the steam consumption of the engine with higher superheat than was obtainable during the first test. The data on this test will be published shortly in POWER, but at this date it may be stated that with approximately 150 lb. pressure and 150 deg. superheat, a steam consumption of close to 15 lb. per i.hp.-hr. was obtained. This test tends to corroborate the figures obtained by Mr. Dean.

S. ROSENZWEIG,
Erie City Iron Works.

Erie, Penn.

Diagrams from an Old Engine

The accompanying diagrams were recently taken from an old beam engine which has been in regular service for about 70 years, during which time the most extensive alteration or repair consisted of fitting a smaller high-pressure cylinder which was done many years ago. The high-pressure cylinder is 25½ in. diameter by 33 in. stroke and the low-pressure is 33 in. diameter by 66 in. stroke. The boiler pressure is 80 lb., and the diagrams show 75 lb. initial and about 24 in. vacuum.

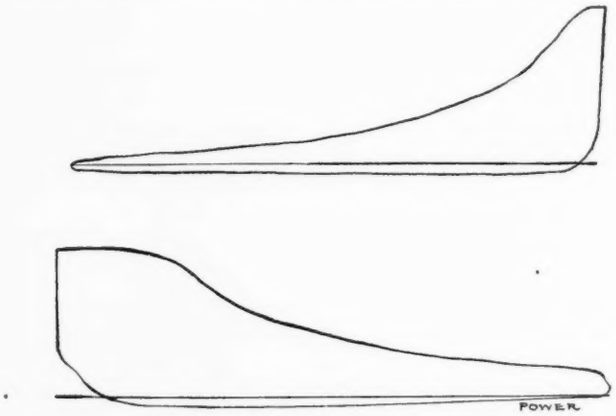


FIG. 1. H.-P. DIAGRAMS FROM AN OLD ENGINE

From all that can be learned concerning this engine the cylinders have never been rebored, although one or two lots of rings have been fitted. Both the beam and connecting-rod are of cast iron, the latter being about 17-ft. centers. The low-pressure cylinder is fitted with piston valves and the high pressure with a quick-acting flat valve.

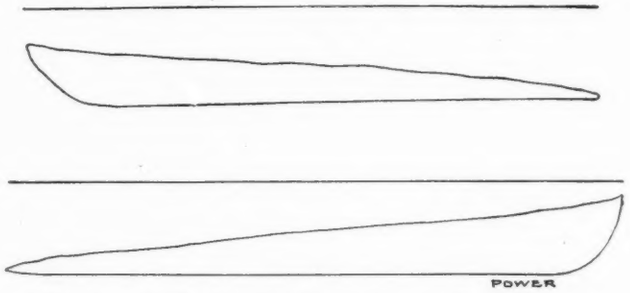


FIG. 2. L.-P. DIAGRAMS FROM AN OLD ENGINE

It is to be observed that the diagrams from the high-pressure cylinder show very fair expansion curves, the form of the diagrams indicating that this old engine is probably quite as economical as many modern engines with the latest types of valve-gears.

E. R. PEARCE.

Rochdale, England.

Clear Water from a Muddy River

It would be useless for the writer to deny the logic or conclusions of A. P. Connor in his especially interesting and valuable article on the above subject, appearing on pages 611 and 612 of the Oct. 28 issue of POWER, but it appears that another cause may be the actual agent in making the above phenomenon possible, and this phenomenon fully complies with the conditions referred to. In regard to the conditions, it may be said that the explicit manner in which they have been set forth enables this writer to go fully into the phases which would tend to bring about the results described in the original article, and which are based on different reasons.

It is a fact that artesian water or flowing wells are common in the region of the lower Potomac at a depth of 30 or 50 ft. below the river level. Assuming that the river referred to is the Potomac, on account of the address being given as Washington, it is my opinion that the crevice in the rock bottom of the river is of sufficient depth (approximately 90 ft.) to be supplied by the same strata of artesian water which is found farther down stream at, say, 50 ft., allowing for the fall in the river. Our geological friends tell us that subterranean rivers are not the source of our artesian water, but rather a percolating process through the rock. Now, Mr. Connor says the water is of a lower temperature than the river water proper; therefore it would settle to the bottom of the crevice, in which case it would carry the sediment with it and would have filled the space long ago. The fact that the crevice is clear and that even rapid pumping does not create a down flow and carry turbid water to the pump suction convinces me that there is an upward flow of

artesian water at this point. This is only in the nature of a supplement to Mr. Connor's article and, I believe, adds interest, geological as well as engineering.

LEON LEWIS.

Washington, N. J.

Mr. Connor's reasons for the presence of clear water in a crevice at the bottom of a muddy river, as expressed in the Oct. 28 issue, do not agree with my theory of the situation. From conditions described in his article it appears that the source of clear water is from a spring in the bed of the river. He states the temperature is approximately 50 deg. F., and varies but little throughout the year.

He also states that in winter the warmer water would be in the crevice at the bottom of the river while the freezing water and ice were on top, and also that the temperature at the bottom of the hole would be about 48 deg. F. in winter.

When water in rivers or lakes gets colder than 39.1 deg. F., which is its temperature of greatest density, it "turns over," that is, the water on the bottom comes to the top and the water on top goes to the bottom. We see from his statement that if the water in the crevice at the bottom of the river was river water its temperature would be 39 deg. F. instead of 48 deg. F., as stated by Mr. Connor.

If the water in the hole was clarified from the river water its temperature would be practically the same on top as on the bottom, for in river waters there are small currents and also the current of the stream which keep the water agitated and the suspended matter in suspension. These small currents are what causes needle and anchor ice to float at all depths in rivers and lakes.

Mr. Connor states that the suspended matter is of a clayey nature. For such substance to settle requires that the water be quiet, and also requires considerable time. As the suspended matter settles to the bottom, what would keep it from entering the strainer and suction pipe? If the water in the hole is in a quiet state, what would prevent the hole from filling up with the sediment from the water. I am of the opinion that the clear water in the hole is from a spring, as the water from springs varies little in temperature throughout the year.

One sure way of telling if the water in the hole is from the river would be to have the waters from the river and hole analyzed. If the analysis is the same for both samples, most likely the water in the hole has its source from the river, but if different it must come from some other source.

LAWRENCE KJERULFF.

Kansas City, Mo.

On page 611 of Oct. 28 issue, A. P. Connor tells how a supply of clear water was obtained from a muddy river. While the facts as given in this instance are truly interesting, it would seem wise to investigate thoroughly before attempting to duplicate these conditions by artificial methods as Mr. Connor suggests might be done.

All running streams deposit more or less solid substance in the low places in their beds, tending to even up the surface over which they flow and had there not been some special reason for the existance of this hole in the river bed no doubt nature would have filled it ages ago. It seems probable that an underground stream finds its way into the bottom of this pit; therefore the flow being upward there is no chance for the muddy water to get into the hole. This would also account for the uniform low temperature of the water.

LEON ROUNDY.

Concord Junction, Mass.

[In connection with Mr. Connor's article and the above discussion of it, it is interesting to read the excerpts below from the Washington *Star* for Nov. 4, 1913.

Why there are no artesian wells in Washington and why some are found as near as Colonial Beach and at other points down the coast is explained in some detail by Olaf A. Ljungstedt, of the Geological Survey. Mr. Ljungstedt takes exception to an article in the "Star" some time ago purporting to explain the geology of the artesian wells south of Washington. The story he refers to made the following statement:

To illustrate how slowly the water travels: Many artesian or flowing wells are found along the Potomac River at Colonial Beach and other points in Virginia, about sixty miles from Washington. This water is obtained by drilling into a sandstone formation which extends along the Potomac valley and into Maryland and outcrops near Frederick, Md., some fifty miles north of Washington. It takes about 100 years for the water of this subterranean river to flow that distance, that is, the rains falling upon the exposed portions of the porous rocks near Frederick sink in and move southward at the rate of about one mile a year.

NO WATER COULD FLOW

Mr. Ljungstedt says that this statement would be interesting if true, but that there is no truth in it. Between Frederick and Washington there is a deep wall of impervious rock, through which no water could flow in a million years. This cuts off Washington and the region to the south from the benefit of any artesian flow from the accumulation of rainwater in the Frederick region. But between that point and the flowing wells at Colonial Beach there is another deposit of pervious rock through which the water can seep, so that the supply for the flowing wells at the beach is of comparatively local origin.

Assuming that the location of the crevice mentioned by Mr. Connor is in the Potomac River and in Washington, it would appear from Mr. Ljungstedt's comment that either the water taken from the crevice is water that seeps in from areas local to the crevice or is river water.—EDITOR.]

Method of Cost Finding

In the Oct. 21 issue, Mr. Milton asks for the method of obtaining the cost per kilowatt-hour of generating electricity in a 200-kw. plant, and gives the cost of labor per day and coal per ton.

This information is too meager to obtain more than a rough approximation of the probable cost of power in this particular plant. The following is the general method employed in determining the cost of power. With this and the information which Mr. Milton presumably has, he should be able to compute very closely the cost for his plant.

The cost of operating power plants is divided into two parts:

(1) Fixed charges.
(2) Operating costs.

Fixed charges cover all expenses that do not vary with the output of the plant. In the average case these consist of interest on the investment required for the plant, depreciation, taxes and insurance.

Interest varies with the nature of the security. Unless definite figures are available, 5 per cent. of the capital invested may be taken as an average figure.

Depreciation represents the amount necessary to be set aside each year at compound interest to replace the plant by the time it has either become worn out or uneconomi-

cal for further operation. General practice shows that the latter cause is usually the one regulating the life of the plant. In most cases 5 per cent. represents a fair charge for depreciation. This is on the basis of a useful life of 14 years and interest at 5 per cent.

Taxes vary with the locality but may be taken at 1 per cent. of the value of the investment if actual figures are not available. The cost of insurance will be about one-half of 1 per cent.

Operating costs may be divided as follows:

Labor.
Fuel and water.
Oil, waste and supplies.
Ash removal.
Repairs and maintenance.

The cost of labor varies so much with the locality and type of plant that this item can be determined only after the exact conditions are known. In New York City firemen can be obtained for about $60 per month, assistant engineers at $80 to $100 and chief engineers at $100 to $125 per month.

The cost of fuel and water is largely affected by local conditions. Also the amount required will depend, to a great extent, on the design of the plant and the economy of the apparatus used. If economical apparatus is installed the first cost and fixed charges will be high and the coal and water charges low, while if an uneconomical plant is installed the reverse will be the case. Obviously the best plant is one in which the sum of these two items is the least. For an average plant of the size under consideration the coal consumption would be about 8 lb. per kw.-hr.

Oil, waste and supplies will approximate from 5 to 10 per cent. of the total operating expenses. For a plant of 200 kw. capacity this item will amount to about $500 per year.

Ash removal may or may not be an item in the operating costs and no predetermined amount can be given unless local conditions are known.

Repairs and maintenance depend to a great extent on the quality of the material and apparatus installed in the plant, and the efficiency of the operating force. Where first-class material and apparatus have been used and a good grade of labor employed it may be taken at about 2 per cent. of the first cost of the plant.

The total cost for generating power depends largely upon the load factor. With a good load factor a plant of this size should be able to generate electricity at a total cost of 3¼ to 3½c. per kw.-hr.

If steam is supplied by the plant for heating, this should be deducted from the total charges as computed above. If the amount of radiation is known the amount of coal required to generate this steam will be about 75 lb. per sq.ft. for a heating season in the vicinity of New York City which is 200 days with an average temperature of 35 to 40 deg. F. For other localities this amount will vary directly with the length of the season and the severity of the climate.

The above estimate is for electricity delivered at the switchboard. In the case of a central station the cost of distribution and lamp renewals must be taken into consideration.

W. L. DURAND.

Brooklyn, N. Y.

Referring to Mr. Milton's request in POWER of Oct. 21 issue relative to cost of power per kilowatt-hour, the following is submitted. We are to consider a 200-kw. direct-connected plant.

The generator manufacturers will guarantee a mechanical efficiency of 91 per cent. for a generator of the above capacity while the manufacturers of a high-grade engine will safely guarantee 90 per cent. mechanical efficiency. Considering the engine and generator as a direct-connected unit, it will have an overall efficiency of 81.9 per cent.; 200 divided by 0.819 gives 245, which shows the work done by the steam engine; 245 divided by 0.746 will, therefore, give the indicated horsepower of the engine, which is 328.

Assuming the engine of this horsepower to be of the compound type we can assume a steam consumption of 23 lb. per horsepower per hour for an engine running noncondensing, since the exhaust steam is to be used at times for steam heating. The steam consumption will, therefore, be

$$328 \times 23 = 7550 \text{ } lb. \text{ } per \text{ } hr.$$

A good boiler will evaporate 9 lb. of water per lb. of coal, so that

$$\frac{7550 \times 24}{9 \times 2240} = 9$$

tons of coal will be required every 24 hr. At $4.50 per ton the coal bill will amount to $40.50. Wages for 24 hr. are stated as $10. To these should be added $0.25 to cover supplies, oil, etc., making a total cost of $50.75 for 24 hr. operation. Therefore,

$$\frac{50.75}{200 \times 24} = 1.06$$

or a trifle over 1c. is the cost of manufacturing a kilowatt-hour. It must be remembered that the above does not take into account repairs, interest, taxes, insurance, depreciation of machinery or cost of feed water which are at times important factors to be considered. All the exhaust steam may not be used for heating so that the engine can be run partly condensing which will decrease the cost of operation. The values assumed may have to be changed to meet the guarantees of the generator, engine or boiler manufacturer, which will change the final result accordingly. The values assumed are fairly safe and the method is general.

Holyoke, Mass. DAVID FLIEGELMAN.

Jacketing of Cylinders

The writer has recently noticed the difference between steam-jacketed locomobile cylinders and flue-gas-jacketed cylinders, observing that, after short service, the flue-gas jacketing imparts a coat of soot which is one of the best heat nonconducting materials. Perhaps many readers of POWER have proved this by getting the bottom of an ordinary kettle covered with soot when it was boiling and then held it on the tips of their fingers, of course being very careful not to break the film of soot, and the question arises as to how much actual benefit is derived by the cylinder from the flue gas after it once becomes coated with soot. It looks as though soot should be very efficient jacketing and a good nonconductor of heat, and I would like to know if any readers of POWER have used it successfully as a covering for pipes or cylinders.

Rochdale, England. E. R. PEARCE.

INQUIRIES OF GENERAL INTEREST

Nonreturn Valve—On what principle does a nonreturn valve work?

E. P.

On the principle of a balanced check valve.

Tobin Bronze—What is Tobin bronze?

A. S.

Tobin bronze is an alloy composed of copper, 61.2 per cent.; zinc, 37.14 per cent.; tin, 0.9 per cent.; iron, 0.18 per cent., and lead, 0.38 per cent.

Diversity Factor—What is meant by the term diversity factor?

A. D. B.

It is the ratio of the sum of the individual maximum demands of the distribution system (which may occur at different times) to the greatest demand on the generating system, during a given period.

Exhaust Noise—What causes the popping sound when a gas or steam engine exhausts into the atmosphere?

J. W. D.

The sudden disturbance of the atmosphere, just as when the surface of still water is struck with a lath producing sudden displacement of air which is extended through the atmosphere as a sound vibration.

Boiler Riveting—In the riveting of boiler seams which is the better, zigzag or chain riveting?

J. L.

Zigzag riveting has the advantages over chain riveting that it requires less lap of the sheets at the joint; that it distributes the strain on the sheets more uniformly along the joint and that it affords better support for calking.

Engine Speeds—Why cannot a Corliss engine be operated at as high a speed as a slide-valve engine?

J. P.

The speed at which a slide-valve engine can be driven is limited only by the pressure of the steam and the strength of the parts of the engine. The speed of a Corliss engine is limited by the speed at which the valve release gearing will operate.

Rust Joint Compound—What is a good formula for a compound for making rust joints?

F. W. D.

The old English formula for rust joint cement was 200 lb. of wrought-iron chips to 2 lb. sal ammoniac and 1 lb. of flour of sulphur. This will set in 24 hr. For quicker setting only about 50 lb. of wrought-iron chips should be used in place of 200 lb.

Erratic Safety Valve—What can cause a safety valve that begins to blow at 100 lb. to continue to blow until the pressure has fallen to 90 lb.?

E. P.

The valve is either held open by friction of the working parts, or else the mechanism is of such a kind or condition that the higher pressure throws the valve out of line preventing its becoming reseated.

Water Hammer—What is "water hammer"?

E. P.

When steam in one part of a system of connected pipes or vessels condenses more rapidly than in another part, a vacuum or reduction in pressure is formed and steam, rushing into this space, carries along any water in its path, causing the water to be driven at high velocity against the sides of the pipe or vessel producing what is called "water hammer."

Cotton Cable Dressing—Is there any treatment which will lengthen the life of cotton cables? We want something that will reduce the wear without causing them to slip.

C. B.

A good dressing for drive rope consists of a mixture of rosin, any vegetable oil and powdered graphite thoroughly ground and mixed, warm. The proper proportions will vary with conditions, climate, etc., but a good average proportion is the following, the parts being by volume: 1 of rosin, 4 of graphite and 8 of oil.

Filling a Lubricator—What is the right procedure when filling a lubricator?

E. P.

To refill a lubricator close the water-feed valve and the regulating valve, and open the drain valve; then remove the filler plug. When the water has all drained out of the oil reservoir close the drain valve, fill the oil reservoir with oil and replace the filler plug. Then to operate the lubricator, open the water-feed valve and adjust the regulating valve to the desired rate of feed.

Compression and Temperature—What effect does the compression of steam in an engine cylinder have on its temperature?

J. H. W.

Pressure increases as volume decreases, and the pressure at any particular point will be practically inversely as the volume. The temperature of the steam at any pressure of the compression will be at least as high as the temperature of dry saturated steam at the same pressure in a boiler and the temperature may rise even higher. When dry saturated steam is compressed without transfer of heat to the piston or cylinder it becomes superheated.

High Compression—Is it possible for steam to be compressed in an engine cylinder to higher than initial pressure? If so, what happens?

J. H. W.

If the exhaust valve closes so early in the return stroke of the piston as to imprison a large volume of exhaust steam, the amount of compression may be sufficient to raise the pressure at the end of the stroke even higher than the boiler pressure and it may stay higher until the steam valve has opened or is forced off its seat. When either happens the compressed steam discharges back into the steam chest until its pressure is reduced to the live-steam pressure in the steam chest, or in common parlance, "is pumped back into the boiler."

Air-Bound Trap—What causes a steam trap (bucket type) to get airbound? Why will water not flow into a trap filled with air the same as if it were filled with steam?

J. W. D.

A steam trap or steam radiator remains "airbound," preventing the admission of steam, because the air is heavier than the steam. When water is presented to the airbound trap, the air is compressed to the same pressure as the water and the viscosity of the water and its friction resist the gravity of the water to displace the air. Dislodgment of the air is also made more difficult, as is commonly the case in water pipes, when the air is in the form of a foam or aggregation of bubbles held together by the viscosity of their liquid envelopes which are gathered up from a pipe or vessel which has contained dirty water.

Pressure Increases—If a volume of 150 cu.in. of water at a temperature corresponding to that of steam at 100 lb. pressure is introduced into a cubic foot of steam at that pressure, will the pressure be increased or decreased?

J. W. D.

Assuming the steam to be dry and saturated, the effect would be the same as if a space containing the 150 cu.in. of water had the original 1728 cu.in. of steam compressed into it until the combined volume was only 1728 cu.in. This would necessarily result in (a) a rise in temperature and pressure of the steam and then (b) a transference of part of the heat of the steam to the water, accompanied by loss in pressure and temperature of the steam until the water rose to the same temperature as the steam. There being more than the original total heat present in the mixture (the additional heat being the heat introduced to compress the steam into smaller volume) the final temperature and pressure would necessarily be higher than the original temperature and pressure.

ENGINEERS' STUDY COURSE

Trigonometry—II

The *complement* of an angle is that angle which added to the first will make an angle of 90 deg. For example, an angle of 30 deg. is the complement of one of 60 deg.; 45 deg. of 45 deg., and so on.

In the diagram, Fig. 4, angle *IAB* is the complement of angle *BAC*. Just as *BC* is the sine of angle *BAF*, *DB* is the sine of angle *IAB*, but *DB* being equal to *AC* is equal to the cosine of angle *BAF*. This shows that *the cosine of an angle is equal to the sine of its complement and the sine of an angle is equal to the cosine of its complement.*

The same might be shown from Fig. 2 (last lesson) for, the sum of the angles of any triangle being 180 deg.

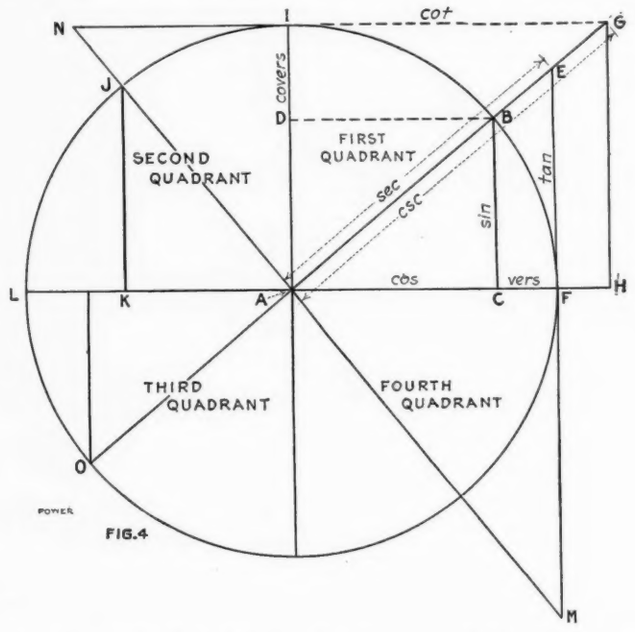


FIG. 4

and the angle *C* a right angle, the sum of the other two angles must be 90 deg.; hence *B* is the complement of *A*.

Just as $sin\ A = \frac{a}{c}$ so also is $sin\ B = \frac{b}{c}$, but $cos\ A = \frac{b}{c}$, hence $cos\ A = sin\ B$.

Similarly in either way it might be proved that *each function of an acute angle is equal to the co-named function of its complementary angle.* In fact, cosine, cotangent, cosecant and coversine are simply abbreviated ways of saying complement's sine, complement's tangent, complement's secant and complement's versine.

It follows from the last rule that *the function of any angle between 45 deg. and 90 deg. is equal to the cofunction of the complementary angle between 0 deg. and 45 deg.* The importance of this is to be observed in connection with the computation of tables of natural functions for it is necessary to carry the tables only as far as 45 deg.

Tables of trigonometrical functions, as they are called, are the values of functions corresponding to angles increasing by degrees or fractions thereof, which have been carefully worked out so that solutions of problems can be quickly obtained without the drudgery of calculating the functions. Such tables are available in handbooks and books of tables and carried out to far greater subdivisions of angles than the abridged table herewith (Table I). The latter, however, will serve to illustrate the use of such a table and will do for such problems as appear in this course.

TABLE I. NATURAL FUNCTIONS OF ANGLES

Deg.	Sine	Cosecant	Tangent	Co-tangent	Secant	Cosine	Deg.
0	0.0000	Infinite	0.0000	Infinite	1.0000	1.0000	90
1	0.0175	57.2987	0.0175	57.2900	1.0002	0.9998	89
2	0.0349	28.6537	0.0349	28.6363	1.0006	0.9994	88
3	0.0523	19.1073	0.0524	19.0811	1.0014	0.9986	87
4	0.0698	14.3356	0.0699	14.3007	1.0024	0.9976	86
5	0.0872	11.4737	0.0875	11.4301	1.0038	0.9962	85
6	0.1045	9.5668	0.1051	9.5144	1.0055	0.9945	84
7	0.1219	8.2055	0.1228	8.1443	1.0075	0.9925	83
8	0.1392	7.1853	0.1405	7.1154	1.0098	0.9903	82
9	0.1564	6.3924	0.1584	6.3138	1.0125	0.9877	81
10	0.1736	5.7588	0.1763	5.6713	1.0154	0.9848	80
11	0.1908	5.2408	0.1944	5.1446	1.0187	0.9816	79
12	0.2079	4.8097	0.2126	4.7046	1.0223	0.9781	78
13	0.2250	4.4454	0.2309	4.3315	1.0263	0.9744	77
14	0.2419	4.1336	0.2493	4.0108	1.0306	0.9703	76
15	0.2588	3.8637	0.2679	3.7321	1.0353	0.9659	75
16	0.2756	3.6280	0.2867	3.4874	1.0403	0.9613	74
17	0.2924	3.4203	0.3057	3.2709	1.0457	0.9563	73
18	0.3090	3.2361	0.3249	3.0777	1.0515	0.9511	72
19	0.3256	3.0716	0.3443	2.9042	1.0576	0.9455	71
20	0.3420	2.9238	0.3640	2.7475	1.0642	0.9397	70
21	0.3584	2.7904	0.3839	2.6051	1.0712	0.9336	69
22	0.3746	2.6695	0.4040	2.4751	1.0785	0.9272	68
23	0.3907	2.5593	0.4245	2.3559	1.0864	0.9205	67
24	0.4067	2.4586	0.4452	2.2460	1.0946	0.9135	66
25	0.4226	2.3662	0.4663	2.1445	1.1034	0.9063	65
26	0.4388	2.2812	0.4877	2.0503	1.1126	0.8988	64
27	0.4540	2.2027	0.5095	1.9626	1.1223	0.8910	63
28	0.4695	2.1301	0.5317	1.8807	1.1326	0.8829	62
29	0.4848	2.0627	0.5543	1.8040	1.1434	0.8746	61
30	0.5000	2.0000	0.5774	1.7321	1.1547	0.8660	60
31	0.5150	1.9416	0.6009	1.6643	1.1666	0.8572	59
32	0.5299	1.8871	0.6249	1.6003	1.1792	0.8480	58
33	0.5446	1.8361	0.6494	1.5399	1.1924	0.8387	57
34	0.5592	1.7883	0.6745	1.4826	1.2062	0.8290	56
35	0.5736	1.7434	0.7002	1.4281	1.2208	0.8192	55
36	0.5878	1.7013	0.7265	1.3764	1.2361	0.8090	54
37	0.6018	1.6616	0.7536	1.3270	1.2521	0.7986	53
38	0.6157	1.6243	0.7813	1.2799	1.2690	0.7880	52
39	0.6293	1.5890	0.8098	1.2349	1.2868	0.7771	51
40	0.6428	1.5557	0.8391	1.1918	1.3054	0.7660	50
41	0.6561	1.5243	0.8693	1.1504	1.3250	0.7547	49
42	0.6691	1.4945	0.9004	1.1106	1.3456	0.7431	48
43	0.6820	1.4663	0.9325	1.0724	1.3673	0.7314	47
44	0.6947	1.4396	0.9657	1.0355	1.3902	0.7193	46
45	0.7071	1.4142	1.0000	1.0000	1.4142	0.7071	45
Deg.	Cosine	Secant	Co-tangent	Tangent	Cosecant	Sine	Deg.

For functions from 45 deg. to 90 deg. read from bottom of table upward.

In this table the functions versine and coversine are omitted because they are very little used. Many tables

also omit the secant and cosecant, the remaining four—sine, cosine, tangent and cotangent—being those most frequently used in calculations.

It is evident how the table is used for finding the functions of any angle up to 45 deg. and based on the explanation just given of the relations between the functions of complementary angles the table from 45 to 90 deg. would be the original table backward, but with the column headings changed to the co-functions. The table, therefore, is used from the bottom up for angles between 45 and 90 deg.

The Four Quadrants

All angles up to 90 deg. are of the first quadrant, as it is called. All angles from 90 to 180 deg. are of the second quadrant, as marked in Fig. 4; all from 180 to 270 deg. are of the third quadrant and all from 270 to 360 deg. of the fourth quadrant.

The sine of an angle extending into the second quadrant as FAJ will be JK which is the same as the sine of the angle JAL. In other words, the sine of any angle, of the second quadrant is the same as the sine of an angle which added to the one in question will equal 180 deg. Such an angle is known as a *supplement* of the first. Similarly it could be shown that all the functions of any angle in the second quadrant are equal to the functions of the supplement of that angle, although certain of them take the negative sign. The tangent of the angle FAJ is FM and is negative. The sine, cosine, tangent and cotangent are negative if the lines that represent them are opposite in direction to the lines that represent the corresponding functions of an angle in the first quadrant. The secant and cosecant are negative if they are opposite in direction to the moving radius. The *moving radius* is the other line of any angle as distinguished from the *fixed radius* AF.

Continuing now to analyze the signs of the other functions of the angle FAJ, the cosine is AK and, according to the above definition, negative; the cotangent is IN, also negative; the secant is AM and negative, and the cosecant is AN and positive.

Similarly the third and fourth quadrants could be investigated, but angles of these quadrants (angles greater than 180 deg. and known as *reflex angles*) are seldom used. It is sufficient to give the following as ways to determine, for any angle what lines represent the functions and whether they are positive or negative.

For any angle the lines representing the functions are:

For the sine, a line from the end of the moving radius perpendicular to the horizontal axis.

For the cosine that part of the horizontal axis intercepted between the center of the circle and the foot of the sine.

For the tangent the line perpendicular to, and from the extremity of, the fixed radius to the moving radius produced (or extended).

For the cotangent the line perpendicular to, and from the end of, the vertical radius dividing the first and second quadrant, to the moving radius produced.

For the secant, the line from the center of the circle along the moving radius produced to the tangent.

For the cosecant, the line from the center along the moving radius produced to the cotangent.

For angles of the various quadrants the signs of the functions are:

TABLE II

	1st Quad	2nd Quad	3rd Quad	4th Quad
Sine and cosecant	+	+	−	−
Cosine and secant	+	−	−	+
Tangent and cotangent	+	−	+	−

All angles of the first quadrant, i.e., all angles between 0 and 90 deg., are more commonly known as *acute angles*, and all angles of the second quadrant, i.e., angles greater than 90 deg. and less than 180 deg., as *obtuse angles*. Angles of 90 deg. are *right angles*, of 180 deg. *straight angles* and all angles larger than 180 deg., as before mentioned, are *reflex angles*.

How to find the functions for acute angles from Table I has already been explained. To find the functions of any obtuse angle subtract the number of degrees in the angle from 180 deg., and in the table find the functions of the supplementary acute angle, whose number of degrees is the difference. The signs of the functions may then be found from Table II.

Example: To find the cotangent of 120 deg.

$$180 - 120 = 60 \text{ deg.}$$

From Table I the cotangent of 60 deg. is found to be 0.5774 and, as shown in Table II, an angle in the second quadrant takes the negative sign, for the cotangent, hence

$$\cot 120 \text{ deg.} = -0.5774$$

Study Questions

6. Having found the functions as called for in the first question (last lesson), find the angle A in degrees from the table.

7. What angle does the guy wire of a steel stack make with the ground if the wire is 100 ft. long and is fastened to the stack 60 ft. from the ground?

8. If the a side of a triangle (Fig. 2, Lesson I) is equal to twice the b side, what is the angle A in degrees?

9. If the angle A is equal to 30 deg., and the side c is equal to 1, what are the other sides of the right triangle?

10. Prove that the sum of the angles of a right triangle is 180 deg.

Last Lesson's Answers

1. $\sin A = \frac{3}{5} = 0.6$, $\cos A = \frac{4}{5} = 0.8$, $\tan A = \frac{3}{4} = 0.75$, $\cot A = \frac{4}{3} = 1.3333$, $\sec A = \frac{5}{4} = 1.25$, $\csc A = \frac{5}{3} = 1.6666$.

2. $c = \sqrt{a^2 + b^2} = \sqrt{24^2 \times 143^2} = 145$

$$\sin A = \tfrac{24}{145} = 0.1655 = \text{also } \cos B$$

because the side adjacent to the angle B is opposite the angle A (see the definitions of the sine and cosine at the top of the second column on page 766).

3. The tangent of the angle or $\frac{a}{b} = 0.8$. Then, if $b = 160$ ft., $a = 160 \times 0.8 = 128$ ft.

4. $\sin A = \frac{a}{c} = 0.6$, $\cos A = \frac{b}{c} = 0.8$. If $c = 240$ ft., then $\frac{a}{c} = \frac{a}{240} = 0.6$, $a = 144$ ft. and $\frac{b}{c} = \frac{b}{240} = 0.8$, $b = 192$ ft.

5. The cosine being equal to the sine of the complement, $\cos 2A = \sin (90 - 2A)$ but $\sin A = \cos 2A$, then $\sin A = \sin (90 - 2A)$ and $A = 90 - 2A$, $3A = 90$ or $A = 30$ deg.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Down in Waycross, Ga., they snatched an editor from his sanctum and set him to guiding the destinies of an electric railway. Good for you, Mr. Rhoads, we always knew that some day one of us scribes would make a hit with the public. As Mr. Rhoads was once a motorman early in his career, this may not be his first hit.

❖

One Mellen, formerly in the New Haven road's employ, predicts that ultimately all railroads will be owned by the government. Some of the roads will be right glad to sell now—and get their money back.

❖

Accompanied by a man equipped with repair apparatus, an aviator will henceforth patrol a Western power company's lines looking for breakdowns. He will make two trips a week. Whadcha know about that!

❖

Does Thomas Lipton really believe that he can win the America Cup? He's challenged again. Suggest his next yacht be named "Oolong," or "Suchow," or "Ceylon." This would fiT The case To a "T." Another cup, Gertie, with a little less sugar, please.

❖

Are we to have a world city? Our state department has directed the diplomats abroad to help boost a $100,000,000-world city, plans for which have been designed by an American sculptor living in Rome. Possible sites suggested are the Jersey coast, The Hague, Rome, Paris, etc. Every nation is to coöperate, but which will get it?

❖

Ought to do better than this: Philadelphia folks have named a new organization for bringing together the bosses and the educators, The Industrial and Technical Education Congress of the Public Education Association. Think of trying to put "T. I. T. E. C. P. E. A." on one badge, for, of course, they'll have a badge?

❖

Wanted, a lady policeman and a male stenographer for Chicago; this is according to that city's civil servicers. There is no insistence that the copperess shall don those bifercated things that chiefly distinguish the male, or that the male stenographer cannot carry his hanky in his cuff or wear a wrist watch. Personally, we hope the lady's first arrest will be that stenographer.

❖

"Did ye iver have a bad fall, Doran?"

"I did, Horan, I've fell from th' state of grace, I've fell full often fer th' loikes of yez, an' oncet I fell off a forty-foot ladder, an'—"

"An' were ye hurted, Doran?"

"No thanks be! I had th' luck to fall off th' first rung an' land on me two feet."

(And then they clinched!)

❖

Flow of Steam in Pipes*

By A. E. Berggren

The size of piping for the transmission of high-pressure steam has come to be of special economic importance to the consulting engineer in the design of steam plants, as he must not allow too great a drop in pressure with pipes too small to carry the load nor must he allow sizes larger than necessary and thereby increase excessively the first cost of the installation. Many tests of piping, both in laboratories and in actual installations, often of special construction, have been made, and valuable data and formulas proposed for the flow of steam through pipes of standard dimensions, but existing data on tests of long pipes are hard to find.

During the summer of 1911 a series of runs was made on the 2400-ft. line of 3-in. pipe carrying high-pressure steam from the Capitol Heating and Power Station to the State Capitol in Madison, Wis. This is one of several in the tunnel connecting the station and the capitol, and all the curves are easy bends of long radius, so that the pipe may be regarded as straight as far as pressure losses are concerned. It is of standard dimensions with screwed, smooth-face, flanged couplings, anchored about every 150 ft., with slip expansion joints of special design at each anchor station. Throughout its length the pipe is covered with 2¼ in. of 85 per cent. magnesia, with molded forms for the flanged couplings. There is a difference in elevation of 76 ft. in the length of the pipe, drainage being toward the station. Ordinary tilt traps are employed with connection to drain pockets on the under side of the special anchor tees and discharging into a separate 2½-in. return main to the sump.

The series of runs was made up of two condensation or no-load runs, in which no steam was delivered, and records only of pressures and condensation were made; and of six proportional loads up to the limit of the 1-in. take-off pipe at the upper end, which was connected to a surface condenser.

The generally accepted formula of Babcock:

$$W = K\sqrt{\frac{y P d^6}{L\,(d + 3.6)}} \qquad (1)$$

where

W = Pounds of steam delivered per minute;
P = Drop in pressure in pounds per square inch;
y = Density of steam at mean absolute pressure;
d = Diameter of pipe in inches;
L = Length in feet;
K = Constant depending on friction;

was checked and for the particular conditions under test was simplified to the following:

$$W = 15\sqrt[1.6]{y P} \qquad (2)$$

This form was found to apply for all loads within reasonable limits, excluding very light and extremely heavy loads, and within the range of pressure drop of 1 to 4 lb. per hundred feet of pipe as allowed in current practice.

To apply to other diameters and lengths of pipe, that part of equation (1) must be included which is a function of the diameter and length. The modified formula for the steam delivered, as derived from these experiments, would be

$$W = 70\sqrt[1.6]{y P}\sqrt{\frac{d^6}{L\,(d + 3.6)}}$$

This modified formula gives the weight of commercially dry steam delivered from a drained pipe, where any condensation due to radiation is taken out at intervals. Babcock's formula gave the correct value, as determined in actual experiment, for one load where the drop in pressure was little over three-quarters of a pound per 100 ft., but gave values increasingly large as the loads decreased, and values decreasingly small as the actual load increased above that corresponding to this drop. It should be noted also that in the modified formula, the coefficient remains constant throughout the ordinary change of load, the weight of delivered steam, or the diameter to be calculated, being dependent on the values of density and pressure drop.

*From an article in the "Wisconsin Engineer."

Changing from Oil Fuel to Coal

By F. V. Hetzel*

SYNOPSIS—Different methods of handling coal and ash for large and small plants with suggestions for existing installations.

With the rise in the price of fuel oil, many power houses in the Southwest are facing the problem of burning coal instead of oil. Heretofore these power houses favorably situated near the oil fields of Texas and Oklahoma have obtained their oil at low cost, but oil prices have been going up so steadily that many managers have come to the conclusion that it will pay them to make the alterations in their boiler houses which a change in fuel will make necessary. Boiler settings must be altered, flues and stacks made larger, and provision made for storing and handling coal and ashes. After the simplicity of piping oil to the boiler furnaces, taking care of coal and getting rid of ashes is a disagreeable necessity, but with the wide-spread use of conveying machinery, coal- and ash-handling equipments for boiler houses have been brought to a state of refinement, and managers who are facing this problem will find that such apparatus can be adapted to any conditions of site, or size of boiler house, or amount of storage.

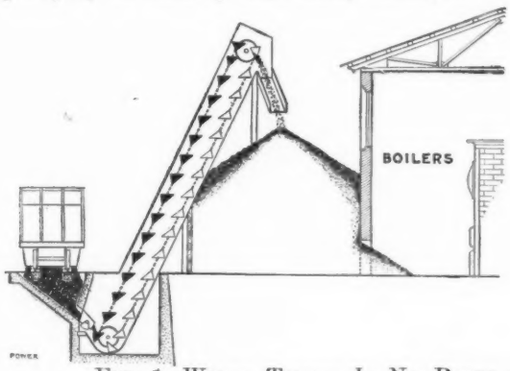


Fig. 1. When There Is No Room for Overhead Storage

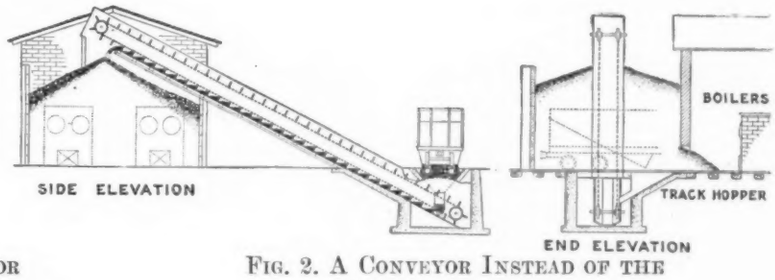


Fig. 2. A Conveyor Instead of the Elevator of Fig. 1

Assuming that there is a railroad siding at the plant, it will be found advisable in most cases to put in a track hopper with a conveyor or an elevator, rather than build a trestle, and dump cars on it. If a trestle dump is used, the coal is spread over a considerable length, and the fireman has to do more wheeling and shoveling to get his coal. Moreover, the first cost of a trestle, and the expensive maintenance of a wood trestle, generally offset what may appear at first as desirable simplicity.

For a hand-fired boiler plant, it is often convenient to store coal just outside the wall of the house, and let the coal flow through holes in the wall to within reach of the fireman. This may suit existing plants when there is no room for overhead storage. In such cases a bulkhead is built parallel to the wall of the house, and the intervening space filled by a chute from the head of an elevator, Fig. 1, or from a conveyor, Fig. 2, or by means of a combination of elevator and conveyor, Fig. 3. The machinery for such a plant is simple and cheap, and the cost of unloading from cars and delivering to bins need not exceed 2c. a ton. For every 100 tons of coal burned, there does not usually result more than 10 tons of ashes. For a small house, it does not pay to install a separate conveyor to gather ashes from in front of the boilers. A wheelbarrow or a hand cart is usually best. An ash elevator and a storage bin are often used, Fig. 5, in such plants; the ashes are stored at a height to flow by gravity into cars or carts, and as they are handled but once, there is no need for the extra labor of loading, as is the case where ashes are piled on a dump until the time comes to take them away.

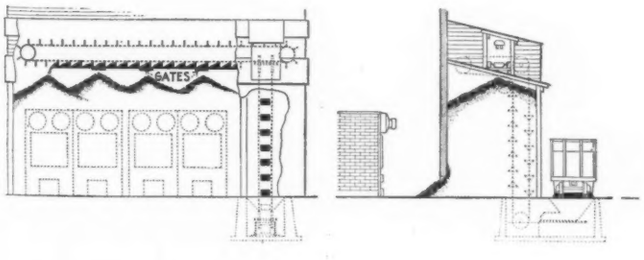


Fig. 3. A Combination Elevator and Conveyor

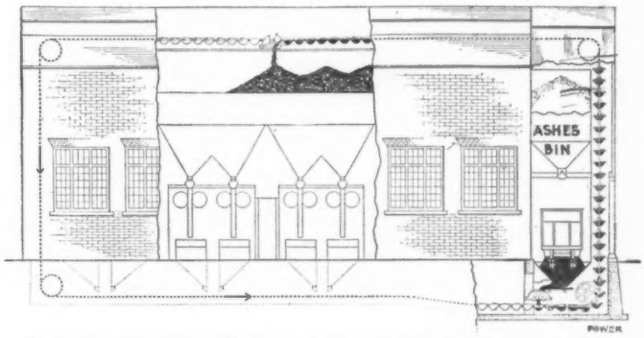


Fig. 4. Typical Installation of Pivoted Bucket Carrier

Since one man cannot fire more than 500 hp. of boilers, under normal conditions, it becomes necessary in larger plants to employ more firemen, or to install stokers and a gravity supply of coal from overhead storage. It may not be possible in all altered boiler plants to install over-

*Chief engineer of Link-Belt Co., Philadelphia and Chicago.

head bins and spouts, but where it is possible, managers should consider not only the first cost of bins and conveyors, but also the fact that the wages of common labor are increasing each year, that in many places it is difficult to hire men for the hot and laborious job of firing boilers by hand, and that it generally pays to invest $5000 in bins and conveyors for every fireman or coal passer whose services can be rendered unnecessary.

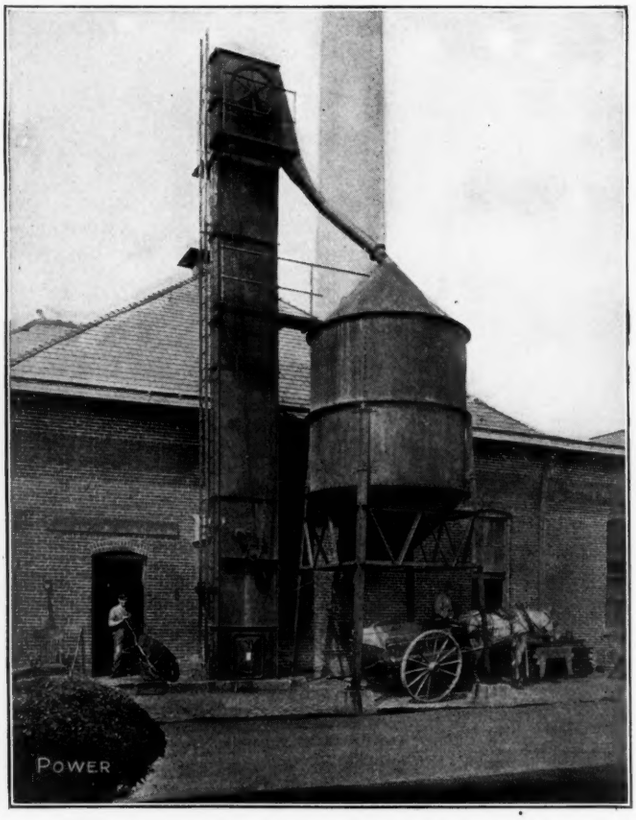


FIG. 5. AN ASH ELEVATOR AND STORAGE BIN

If overhead storage is decided on, the bins can be separate for each boiler, or one long bin can be used. The latter is the cheapest way to get a large amount of storage, particularly if the bin is of the suspension or bag-

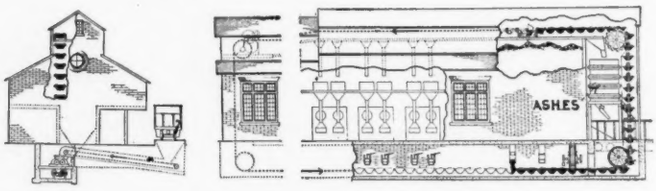


FIG. 6. AN INSTALLATION SIMILAR TO THAT OF FIG. 4

bottom form. The bin should be high enough to permit boiler tubes to be cleaned or removed, and there should be room enough over the bin to put in the coal conveyor. The bin can be filled by a separate coal conveyor, but since in most large plants the problem of quickly disposing of ashes is an important one, a convenient way is to combine the coal conveyor and the ash conveyor in one, and use a machine of the pivoted-bucket type. Figs. 4 and 6 show typical installations of pivoted-bucket carriers. These include a track-hopper dump, a feeder of some kind, a crusher and the carrier taking coal from the crusher and delivering it to the overhead bins, or taking ashes from the hoppers under the boilers and delivering them to the ash storage overhead. If there is no basement for the lower run of the carrier, or if hoppers cannot be built under the boilers, all that is necessary is a trench in the boiler-room floor to receive the carrier. Ashes are then raked from the boiler ashpits into the lower run of the carrier.

Pivoted-bucket carriers are of several forms. A type quite commonly used has overlapping lips, see Fig. 7, to prevent the spill of material between the buckets. Cams or strikers on the ends of the buckets engage a dumper which travels along the top run, and the contents of each bucket are poured out at any point desired.

These general remarks may throw some light on the methods to be adopted in installing coal and ash machinery in boiler houses which now burn oil. Each plant will present some peculiarity of location or of arrangement, which will call for particular treatment and the experience of engineers trained to this kind of work.

The Sturtevant Air Washer

The new Sturtevant air washer, Fig. 1, which has been on the market a little over a year, is of the rain-spray type, with horizontal eliminators. It consists of three parts, the spray chamber, in which the washing actually occurs, the eliminators, which remove all entrained moisture from the air and the sump, or tank, which forms the bottom of the air washer and into which falls all of the air from the syray pipes and the eliminators.

Besides these parts, there is a recirculating pump for creating a circulation of water in the spray pipes. When installed in a ventilating system, the arrangement shown in Fig. 2 is used. The air enters at the left, passes through a tempering coil and heater into the air washer and from thence through a second heater into the fan. The pump and water piping are shown and a portion of the casing is broken away, showing the eliminators of the air washer.

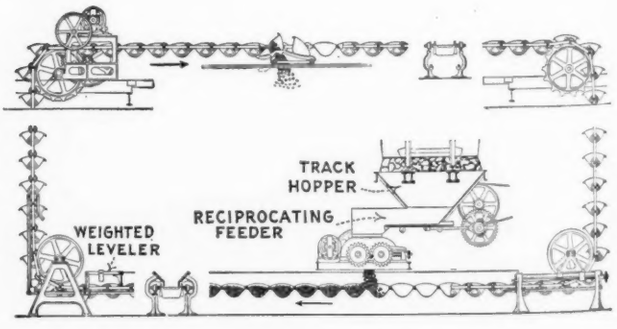


FIG. 7. A FORM OF PIVOTED BUCKET CARRIER

The type of nozzle forming the spray in the air washer, which is made by the B. F. Sturtevant Co., Hyde Park, Boston, Mass., is shown in Fig. 3. Fig. 4 shows how these are attached to the spray pipes. The design of these nozzles permits of a large orifice which prevents clogging, and no flushing device is required with this type of nozzles. The water issuing from the orifice under pressure created by the recirculating pump strikes against a lip curved over this orifice and is broken into a spray, spreading out broadly, due to the shape of the lip and thus completely filling the chamber. The water falls into the sump below. The spray chamber is constructed of gal-

vanized steel and the interior is painted with black asphaltum.

The air passing through this rain-like spray is cleansed of dirt and impurity and finally comes in contact with the eliminators, whose position in the air washer can be seen in Fig. 1, and whose shape and construction can be seen in Fig. 5. These eliminators are placed horizontally across the air washer and form between them, broken passages through which the air must pass in order to leave the spray chamber.

The surface of each of the eliminators is perforated in such a way that small lips of metal are formed and that the edge of each eliminator is serrated. The air laden with moisture strikes against the edges of these serrations and perforations and against the edges of the metal lips where the entrained moisture is removed so that when it leaves the eliminators, the air contains no unevaporated moisture. The water dripping from these eliminators further

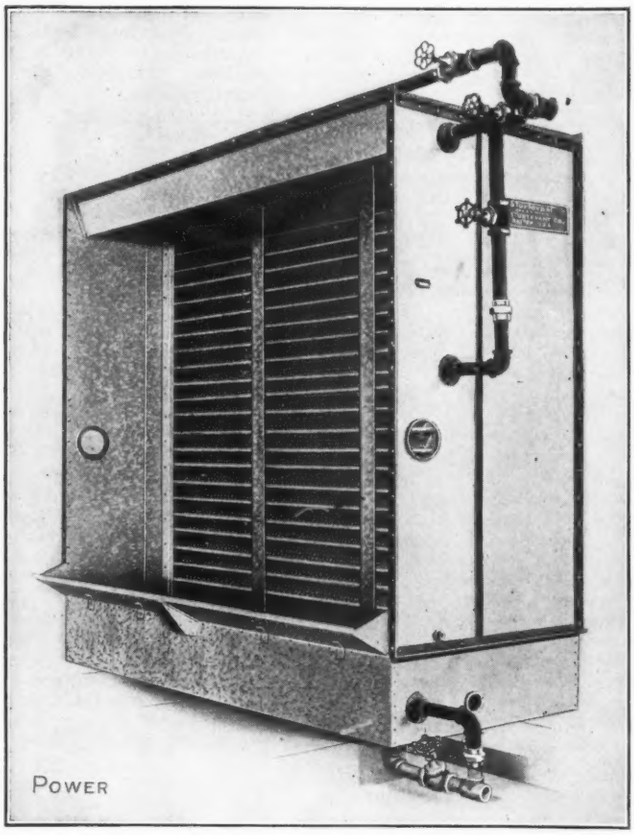


FIG. 1. STURTEVANT AIR WASHER

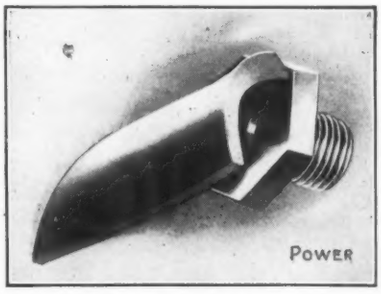


FIG. 3. SPRAY NOZZLE OF AIR WASHER

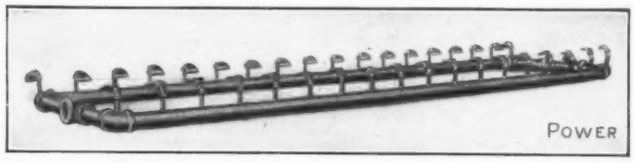


FIG. 4. SPRAY PIPE SHOWING NOZZLE ATTACHMENT

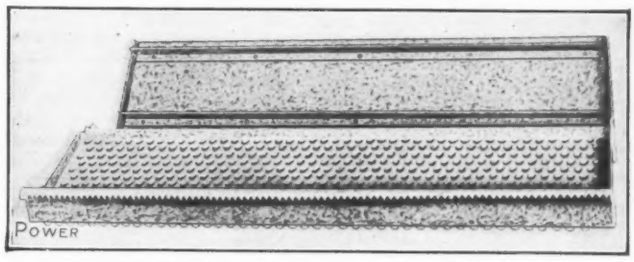


FIG. 5. ELIMINATOR OF AIR WASHER

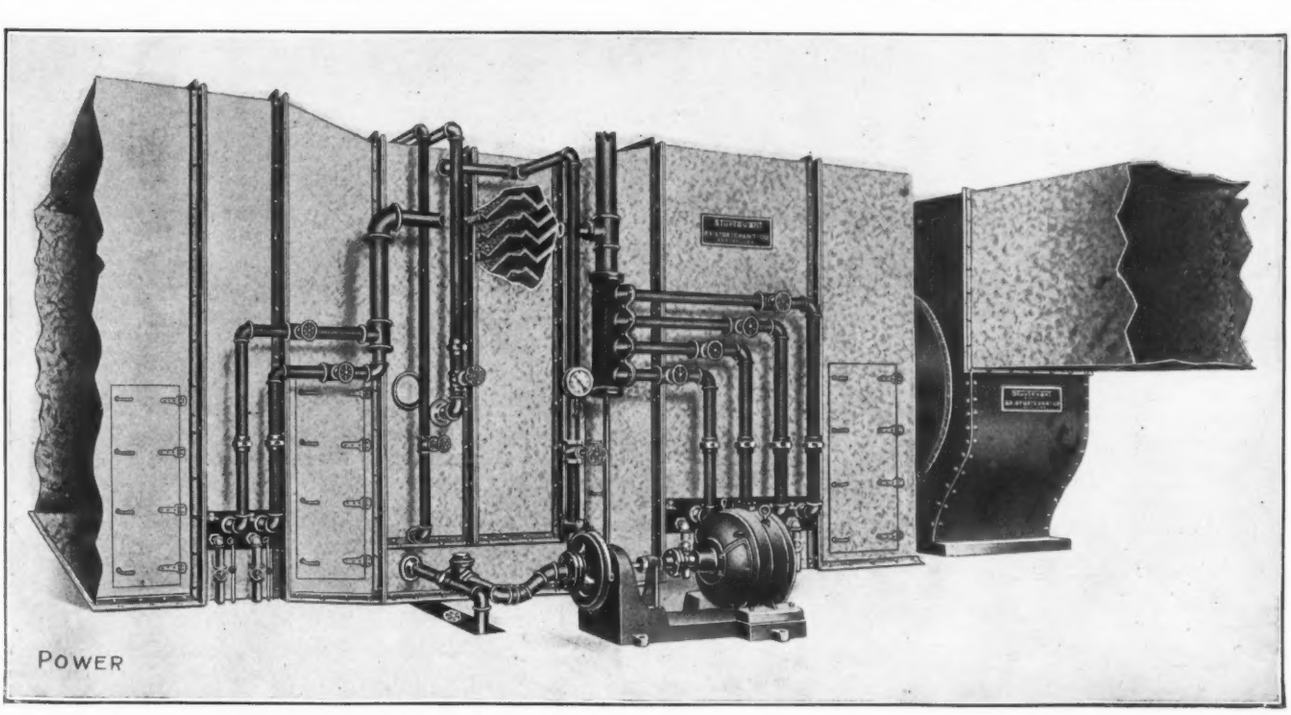


FIG. 2. AIR WASHER ARRANGED WITH TEMPERING COIL, HEATER AND FAN

increases the efficiency of the washing process and drains into the sump below. The eliminators are constructed of galvanized steel, galvanized after being punched and formed, and painted with black asphaltum.

The sump, which may be constructed of galvanized iron or of concrete, is a tank into which falls the water from the spray chamber and eliminators. It is provided with an overflow which maintains a constant level of water within and with a drain and strainer. A float valve maintains the water supply. The water is drawn from the sump by a small centrifugal pump, shown in Fig. 2, and is delivered by this pump to the spray pipes under sufficient head to create the desired spray. The pump may be driven by electric motor, pulley, belt, steam engine or steam turbine.

The strainer consists of two concentric, perforated cylindrical screens inclosed at the ends by aluminum castings. The pump-suction pipe draws the water within the two screens. As the orifices of the nozzles are comparatively large, the mesh of the strainer is not so fine that excessive power is required to drive the pump and as a second wire strainer in the washer pipe is unnecessary, another saving in power for the pump is thereby effected.

The Ohio Society

The Ohio Society of Mechanical, Electrical and Steam Engineers held its 28th meeting at Columbus, Nov. 20-22. Thursday forenoon the arriving members gathered at the Southern Hotel for registration, and in the afternoon visited the Seagrave Co., makers of auto-truck apparatus for fire departments, and the Buckeye Steel Castings Co., while the ladies were taken about the city in automobiles. On Thursday evening a professional session was held at the auditorium of the Southern Hotel, at which Geo. S. Cooper, mechanical engineer, of the Buckeye Engine Co., of Salem, Ohio, read a paper upon "An American Locomobile," describing the first American locomobile, or the Buckeye-Mobile manufactured by that company and described in "Power" for May 20, 1913. The portions of the paper other than the descriptive will be reproduced in an early issue. Remarks were made by Mr. Bassell, of the Columbus Publicity Association, and Mr. McMean, president of the street railway. Friday was spent at the Ohio State University, where, in Townsend Hall, a meeting of the council was called for 9 a.m., followed by a business meeting of the society, at which W. C. McCracken, chief engineer of the Ohio State University, was elected president; W. L. Brown, of Toledo, vice-president, and Geo. S. Cooper, of Salem, Ohio, and Dan Delaney, of Cincinnati, managers for the ensuing year. Following the business meeting a paper upon "Steam Flow Meters" was presented by Irving B. Terry, of the Cincinnati office of the General Electric Co.

The afternoon was devoted to an inspection of the engineering laboratories and plants of the university, with a lecture by Francis G. Caldwell, professor of electrical engineering at the university, upon the "Quartz Tube Mercury Vapor Lamp."

The visitors were the guests of the local committee at the Union, the University Club House, at luncheon and dinner. In the evening a professional session was held in the Physics Building, at which papers upon "Accident Prevention," by Fred G. Bennett, head of the Safety Department of the Buckeye Steel Castings Co.; "Recent Developments in Electrical Transmission," by Geo. N. Lemmon, general manager of the Transmission Engineering Co., of Pittsburgh, and a paper upon "Carborundum," by Chas. Boultman, of the Carborundum Co., were presented. Meantime, the ladies attended the theater. On Saturday visits were made to the Automatic Exchange of the Citizens' Telephone Co., the filter works and pumping stations, and other local industries.

NEW PUBLICATIONS

GAS AND FUEL ANALYSIS By Alfred H. White. Published by McGraw-Hill Book Co., New York, 1913. Cloth, 5½x8 in.; 276 pages, 47 illustrations, tables. Price, $2 net.

The ever-spreading tendency to control industrial processes by scientific investigation of the character of the materials handled makes this volume timely. Gas analysis is a useful method of controlling the operation and checking the efficiency of boilers, producers, gas-making plants, etc. To get the greatest benefit, the analysis must be as nearly accurate as possible. The author points out many causes of error not commonly recognized and rarely fully appreciated. For instance, it is reasonably well known that plain water has ability to absorb CO_2, but it is not well known that the error due to the absorption of CO_2 from the sample of flue gas collected over water may amount to as much as 50 per cent. of the CO_2 content of the gas if the water is not saturated with the gas being tested.

The book contains many useful hints on handling the apparatus required. To illustrate, it is pointed out that the stop cock of a gas burette, a source of frequent error and trouble, should be kept clean and well lubricated. The author states that vaseline, commonly employed, is inferior, and favors anhydrous lanolin. Rubber connections cannot be relied upon to remain gas-tight for long periods of time, and it is recommended that all such connections be reinforced by soft copper wire wrapped once around the connection and clinched.

Both absorption and explosion and combustion methods of determining the content of hydrogen, methane, ethane and carbon monoxide are discussed. The chapter on the absorption reagents employed is valuable, because it points out their limitations.

In the chapter on gas calorimetry the available methods and types of apparatus are discussed and considerable space is given to the design and operation of Junker's continuous-flow calorimeter. In another section gas photometry in considerable detail is taken up; several types of photometers are described and the methods of procedure fully explained. Separate chapters deal with estimating suspended particles in gas, chimney- or flue-gas analysis, producer-gas and illuminating- and natural-gas analysis.

The chapter on liquid fuel takes up the usual tests applied, such as for heat value, specific gravity, moisture, suspended solids and flash point.

SOME OF THE ATTENDANTS AT THE COLUMBUS MEETING OF THE OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

The sampling, analyzing and testing for heat value of coal is treated in three chapters or 66 pages. Interesting data are given relative to the possibility of error due to sampling. One illustration of possible error even with what many would consider adequate care is particularly interesting. A lot of three tons of run-of-mine coal was moved in wheelbarrows.

As each barrow was filled a shovelful of coal was put into each of 16 sampling barrels. After the coal was moved, the barrels each contained about 125 lb. of coal. These samples were crushed and sampled carefully and the ash in each determined. Only two of the samples exactly agreed while two disagreed by 4.46 per cent. In one case the ash content was shown as 9.46 per cent. and in the other 13.92 per cent.; the average for all 16 analyses was 10.68 per cent. The possibility of error induced by the presence of lumps of slate in the coal and the influence of size are also strikingly brought out. The chapters on coal analysis and heat value go into considerable detail and several types of calorimeters are discussed.

This is the most complete and exact modern treatise on the subjects embraced that has come to the notice of the reviewer. The book shows that the author is thoroughly familiar with the work in both its academic and practical phases and hence will be found of service in commercial as well as scientific practice.

HANDBOOK FOR HEATING AND VENTILATING ENGINEERS. By James D. Hoffman. Published by McGraw-Hill Book Co., New York City, 1913. Flexible leather cover; 402 pages, 4½x7 in.; 157 illustrations; tables. Price, $3.50, net.

This is the second edition of a handbook which covers the entire field of heating and ventilation, with two chapters on refrigeration. The first edition appeared in 1910. For the present edition all the material has been revised to bring it up to date. The work on air conditioning has been amplified. Descriptions of hot-water and steam heating have been improved by diagrams of the various piping systems. Two chapters have been added on refrigeration, and also a number of useful tables in the appendices. The first chapters of the book deal with elementary considerations, such as the measurement of heat and temperatures, composition of air, humidity, measurement of air velocity, etc. This is followed by a chapter on heat losses from buildings, and methods of estimating the radiating surface required. The information given in this chapter is excellent, as the computations for hot-steam and hot-water systems are treated in the same way. In the days of vapor systems operating on low temperature steam it is illogical and incorrect to assume that steam systems require any more or less radiation than hot-water systems when operated under like average temperature conditions. Considerable space is given to hot-air furnaces, which should be appreciated by those engaged in that line of work. There seems to be the same doubt and confusion as to requirements of heating surface for the hot-air furnace, as occurs in the cast-iron boiler trade. The book is lacking in definite data on both furnaces and heating boilers outside of the general ratios of grate to heating surface. This information does not appear, however, in any of the current literature on the subject, and is very probably a reflection of the attitude of the boiler manufacturer in not giving this important item in his catalog. Along this line attention is called to results of a test on an American Radiator Co.'s boiler given in the second appendix of the book. The data may perhaps shed some light on how some of the catalog ratings are obtained. In a boiler containing 300 sq.ft. of heating surface an evaporation of 5.6 lb. per sq.ft. of surface per hr. was given. Assuming that this evaporation is from and at 212 deg. F., it would require only 6.12 sq.ft. of surface per horsepower, as compared to 10 sq.ft. for the best power boilers. This would make the evaporation per square foot for a power boiler 3.45 lb. as compared to the 5.6 lb. given above. Ordinarily the efficiency of a power boiler should be higher than that of a cast-iron boiler, and especially when the stack temperature of the latter reaches 725 deg., which was the figure given in the test.

The various systems of hot-water and steam heating, mechanical warm-air heating and district heating, are given extended attention. This is followed by a chapter on temperature control, a chapter on electric heating, two chapters on refrigeration, a chapter dealing with specifications, and two appendices giving a number of valuable tables and diagrams. The chapter devoted to district heating, although possibly reflecting past practice in the West, is rather misleading in some respects as to the possibilities of central heating by hot water. It is stated that "With perfected apparatus for removing oil, the commingler will no doubt supersede to a degree the tube reheaters in hot-water heating." On the next page it is stated that the pressure in the radiators is greater on water systems than on steam systems, especially when connected to high buildings. The use of a commingler precludes any very high building heating, due to the fact that there is an open circuit, and all water has to be pumped against the total static head and friction head of the piping, which is, of course, very uneconomical. In a diagram showing the power-plant layout in connection with a hot-water heating system, piston pumps are shown, although they have been discarded by all modern engineers for this class of work, and with a live-steam heater it is unnecessary to have any of the boilers arranged for water circulation as shown in the illustration.

In the tabular matter Peabody's tables giving properties of steam have been used rather than the tables of Marks & Davis, which have now been more generally accepted as standard. The properties have not been given below 1 lb. abs., although in air conditioning they are needed down to 32 deg. F. Wood's tables giving the properties of ammonia have also been used rather than the later, and more accurate data brought out by H. J. MacIntire, or the tables of G. A. Goodenough and William E. Mosher, published in a bulletin of the University of Illinois Engineering Experiment Station.

As a whole, the book is excellent and admirably adapted for reference or to supplement more specialized works. At the end of each chapter references to technical books and periodicals are given, which alone are worth the price of the book, and with every copy a pamphlet is included containing suggestions and problems for a course of instruction in technical schools. The latter feature should be appreciated by the instructor, and of value to the practical man or student, as answering the numerous questions given will test their knowledge of the subject and indicate their deficiencies.

Space Occupied by Water-Tube Boilers is the title of an interesting pamphlet which has recently been issued for general distribution by the Heine Safety Boiler Co., of St. Louis. This publication is a reprint of a paper read last April by C. R. D. Meier, general sales manager of the company, before the Associated Engineering Societies in St. Louis. The paper considers the influence of tube size and arrangement, gives the dimensions of seven water-tube boilers of the same rated capacity, the comparative floor space required for a typical installation of eight boilers of the various types, discusses the money value of floor space and head room and finally the total saving per boiler horsepower from the standpoint of floor space and head room saved.

⁂

Class in Heating and Ventilation

A class in the science and practice of heating and ventilation will meet Monday evening of each week at 7:30 o'clock, in Room 511, World Building, New York, and the course will be under the direction of a competent heating and ventilating engineer, who is engaged in the design and installation of systems for all classes of buildings, and is well fitted to offer the best instruction in the most recent practice. The course will consist of 22 lectures covering the subjects of heating and ventilating, with special reftrence to such topics as purification of air; types of heating systems; computation of heating surfaces; pipe sizes; ducts; fans; radiating surfaces, etc. The fee for the complete course will be $10, payable in advance.

The first meeting was held on Dec. 1, at 7:30 p.m., to organize regular classes, and the lectures started the following Monday evening.

⁂

Power Companies at Sault Ste. Marie, the Michigan & Lake Superior Power Company and the Algoma Steel Corporation, were given hearings on Oct. 7 by the International Joint Commisions, on their applications to be allowed to divert water at Sault Ste. Marie by an international dam.

⁂

A Power Plant at Great Falls, in the Potomac River near Washington, is to be built if Congress is favorable to a recommendation to be made to it by the Commissioners of the District of Columbia. The commissioners have included in the District appropriation bill an item of $3,000,000 to provide for the purchase of the falls and the beginning of the work, the total cost of which, it is estimated, would be $15,000,000.

⁂

A rubber belt 700 ft. long, 2 ft. wide, and tipping the scales at 5140 lb., was recently made by the Goodyear Tire Rubber Co. Akron, Ohio. It is to be used as a conveyor belt. When made into a roll it made a diameter greater than the height of an average size man.

Life of Isolated Plants

At the meeting of the New York Society of Architects, Nov. 18, at the Engineering Societies Building, New York City, Charles M. Ripley, with the firm of Pattison Brothers, consulting engineers, gave a talk on "The Life of Private Electric Plants and Are They Popular?" Investigating a list of about 150 of the large buildings in New York, selected impartially from a tax list, it was found that, as measured by assessed valuation, 78 per cent. furnish their own current. These buildings were of all kinds, including office buildings, apartments, hotels, theaters, railroad stations, clubs, etc. Naturally among such buildings as hotels and railroad stations where the hours of service are most continuous the percentage of private plants is high, while nearly all theaters and other places having need of current for relatively few hours in the twenty-four, purchase it.

The remainder of the talk, dealing with the life of plants covered two divisions, one a search and the other an investigation. The search was for the oldest plants in New York City still operating. The oldest located was that in the Mills Building, which has been in operation 32 years. Others ranged from this length of life down. As it was impossible to tell how many plants had gone out of existence in this time, it was believed unfair to draw conclusions as to the life of plants from the survivors, these being possibly the exceptions. The investigation, therefore, covered all the plants installed by the one firm of engineers to whose records the speaker had access, and extended back over twenty-three years. None of the plants designed by this office are dead. All but two are still operated and the two exceptions are not dismantled, but are retired for the present.

To draw conclusions as to proper rates of depreciation the speaker had asked Edward M. Hyams, president of the Certified Audit Co. of America to give him the number of years required for a sinking fund to equal the original investment; the sinking fund to earn 4½ per cent. interest, compounded annually.

This was given as in the following table:

Depreciation charged off annually	Years required to refund investment
1½	Between 31 and 32 yr.
2	26 and 27 yr.
2½	23 and 24 yr.
3	20 and 21 yr.
3½	18 and 19 yr.
4	17 and 18 yr.
4½	15 and 16 yr.
5	14 and 15 yr.

From this the following was figured:

SUMMARY OF PROBABILITIES

34 plants designed before 1900, 5% depreciation too much.
29 plants designed before 1898-9, 4½% depreciation too much.
17 plants designed before 1897, 4% depreciation too much.
15 plants designed before 1895-6, 3½% depreciation too much.
4 plants designed before 1893-4, 3% depreciation too much.
1 plant (N. Y. "Herald") 3% (may or may not be) too much.

SUMMARY OF POSSIBILITIES

Plants installed between 1883-1900

16 show less than 3 per cent. depreciation.
12 show less than 2½ per cent. depreciation.
4 show less than 2 per cent. depreciation.
1 show less than 1½ per cent. depreciation.

Cover of Receiving Tank Injures Two

Excessive pressure in a large exhaust steam receiver used to distribute steam for heating the building of the Fremont (Ohio) Furniture Co., blew off the handhole cover. It divided into a number of small pieces, some of which hit the engineer in the face and cut his cheek and chin. An employee of the plant received the full force of the escaping steam and was badly scalded on the face, neck and left arm. Both were removed to their homes and will be confined for some time.

New Haven A. S. M. E. Meeting

The New Haven local meeting of the American Society of Mechanical Engineers was held in the Mason Laboratory of the Sheffield Scientific School, Yale University, Friday, Nov. 21, 1913. At the afternoon session the general topic was "Co-operative Industrial Research." E. S. Cooley, supervisor of power plants of the New York, New Haven & Hartford R.R., the Connecticut Co., and the Housatonic Power Co., and chairman of the local committee on meetings, presided.

The subject was introduced by Dr. L. P. Breckenridge, professor of mechanical engineering at the Sheffield Scientific School, by outlining the relations of this school to Connecticut manufacturers and others in the carrying out of industrial research. O. P. Hood, chief mechanical engineer of the United States Bureau of Mines, followed with an explanation of the research work of the bureau and W. K. Shepard, representing the Engineering Experiment Station of the University of Illinois, read a paper on "Coöperation of State and University for Industrial Research."

In the interval between the afternoon and evening sessions and again after the evening session opportunity was afforded to witness demonstrations in the laboratory of oxy-acetylene cutting and welding by Henry Cave, president of the Autogenous Welding Equipment Co., Springfield, Mass., the new automobile-testing apparatus in the laboratory and recent types of pneumatic tools.

At the evening session an address was made by Calvin W. Rice, secretary of the American Society of Mechanical Engineers, in the course of which he announced some of the special features of the annual meeting of the society to be held in New York City, Dec. 2-5, and referred to the growth of the society in recent years.

The papers which followed included one on tests of safety devices used in connection with grinding wheels, by R. G. Williams, of the Norton Co., Worcester, Mass.; an analysis of the difference in conditions here and abroad as affecting the protection of life and limb of the people and the taking of precautions for safety by Dr. A. D. Risteen, of the Travelers' Insurance Co., Hartford, Conn.; and one on the manufacture of brass, comparing practice in Austria, Germany, France, England and the United States, by W. B. Edwards, of Ansonia, Conn.

Two other papers scheduled for the meeting had to be omitted on account of shortness of time. One of these dealt with experiments with residence-heating boilers by D. B. Prentice, of the Mechanical Engineering Department of the Sheffield Scientific School, and the other with motor-car testing by E. H. Lockwood, assistant professor of mechanical engineering at Sheffield.

At the evening session, which was the larger of the two, there were about 250 persons present.

SOCIETY NOTES

At the semimonthly meeting of the Detroit Enginering Society, on Dec. 5, James V. Oxtobyon will read a paper on "The Relations of the Engineer to the Law." On Dec. 19, the society will discuss a new constitution.

On Wednesday evening, Nov. 19, the Chicago section of the American Society of Mechanical Engineers held the first of a series of informal dinner-discussions planned for the 1913-1914 season, in the Crystal room of the Sherman Hotel. The topic was "The Steel Industry," the discussion being led by W. A. Field, general superintendent of South Works of the Illinois Steel Co. Over 150 members and guests sat down to the dinner at 6:30 o'clock. The occasion was distinguished by the presence of President W. F. M. Goss, Past-presidents R. W. Hunt and Ambrose Swasey. Among the other speakers were Edward McKim Hagar and H. J. K. Freyn. Paul P. Bird presided.

PERSONALS

John Thompson, formerly chief engineer for the State Normal School, Trenton, N. J., has been appointed chief engineer for the new City Hospital, in Newark, N. J. Mr. Thompson has already assumed his new duties.

William A. Vreeland, of Newark, N. J., formerly chief engineer of the L. Bamberger Co. department store, Newark, has been appointed inspector for the Passaic Valley Sewerage Commission. Mr. Vreeland will have charge of all mechanical equipment and buildings connected with the pumping and disposal of sewage carried by the large trunk sewer.

C. L. Newcomb, Jr., will succeed G. B. Turner as Western representative of the Goulds Manufacturing Co., Seneca Falls, N. Y., with headquarters at 12 Chamber of Commerce, Denver, Colo. Mr. Newcomb will look after the company's interests in the Rocky Mountains and Northwestern territories. He has had several years' experience in the pump business and is well known in the territory he will travel.